# EVALUATION OF FIRE APPARATUS DESIGN CHANGES IN THE NORFOLK DEPARTMENT OF FIRE AND PARAMEDICAL SERVICES

STRATEGIC MANAGEMENT OF CHANGE

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**Abstract**

The design and performance of fire apparatus must be routinely evaluated to ensure that the needs of both the fire department and the community are being met in a cost-effective manner. When appropriate, bid specifications should be revised to improve the design of future purchases. The problem was the Norfolk Department of Fire and Paramedical Services (NFPS) had never formally evaluated its new fire apparatus.

The purpose of this research project was to evaluate the design and performance of all new fire apparatus purchased by the NFPS between Fiscal Years 1995 and 1997. An evaluative research methodology was used to answer the following questions:

1. How have the new fire apparatus purchased between Fiscal Years 1995 and 1997 impacted the NFPS?

2. What is the opinion of NFPS personnel on the performance of the new fire apparatus purchased by the department between Fiscal Years 1995 and 1997?

3. What is the opinion of personnel from other career fire departments on the performance of new fire apparatus of similar make and models to that purchased by the NFPS?

The procedures used to complete this research included a review of fire service literature and Norfolk City documents and records, and opinion surveys of NFPS personnel and personnel from other fire departments that have similar fire apparatus.

The results of this research presented distinct implications for the NFPS including the need to enhance apparatus replacement forecasting methods, improve record keeping on apparatus "down-

time," improve design and performance features on future apparatus, and base apparatus mission statements on actual as opposed to perceived needs.

Recommendations included improvements in the areas of data collection, fire apparatus mission requirements, apparatus research, specification development, regulations and standards, personnel accommodations, equipment accessibility, operational performance, and fire service political activity.

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## Introduction

The design of modern fire apparatus is far different from that envisioned by Richard Newsham, a British engineer who manufactured and exported some of the first fire engines to the towns and cities of colonial America. Since that time, fire apparatus have evolved from crude, manually operated pump-carts, to motorized vehicles equipped with high performance diesel engines, large volume fire pumps, and heavy-duty aerial ladders (Buff, 1991).

The traditional organizational goals of the fire service have shifted in recent years from a narrow focus on fire protection and fire prevention activities, to a broader spectrum that includes services such as emergency medical care, technical rescue, and hazardous materials response. This organizational transformation has prompted changes in the fire apparatus design requirements of many fire departments. Modern fire apparatus must be engineered to meet the demands of repeated emergency responses, many of which do not involve the deployment of hoses and the application of water. Furthermore, apparatus bodies, suspension systems, and chassis frames must be capable of supporting the increased equipment loads required for multi-faceted fire service missions.

The fire apparatus industry has responded to the changing needs of the fire service by introducing a number of innovations over the past ten years. These innovations include the introduction of electronic controls, an increase in gross vehicle weight ratings, the re-introduction of multi-service units such as quints, the adaptation of the standard pumper body to allow increased compartment space, and an increase in load ratings for aerial devices (Peters, 1996). Although these innovations

have greatly improved the ability of the fire service to meet present demands, some have been openly resisted in the firefighting community.

Firefighters and mechanics alike often express concern over the reliability of electronic controls on emergency vehicles, and the level of training and expertise necessary to affect repairs when needed. In addition, many firefighters argue that the increased heights of hosebeds and storage compartments on multi-service units restrict access to hose and essential equipment, which can negatively impact firefighting operations. Moreover, fire chiefs in some localities have debated the cost effectiveness of dispatching large, heavy, fire apparatus to handle emergency medical and general service calls (Adams, 1996).

The purchase of new fire apparatus has become a major capital expense for many municipalities. Apparatus pricing can range between $ 100,000.00 and $ 650,000.00, depending on the type of vehicle and the options specified (Peters, 1996). Thus, local governments must carefully plan for the replacement of individual fire apparatus at regular intervals to ensure that adequate fire protection is maintained and to avoid the financial impact of replacing multiple units during a single fiscal year.

Because it is a vital element in public fire protection and requires a substantial investment of public funds, a new piece of fire apparatus must be routinely evaluated to ensure that it adequately meets the needs of both the fire department and the community in a cost effective manner. When appropriate, bid specifications should be revised to improve the design of future purchases. The problem that prompted this research project was the Norfolk Department of Fire and Paramedical

Services (NFPS) had never formally evaluated the design of new fire apparatus purchased in accordance with a multi-year replacement program that was implemented in 1994.

The purpose of this research project was to evaluate the design and performance of all new fire apparatus purchased by the NFPS between Fiscal Years 1995 and 1997 to determine if it adequately met the needs of the both the department and the citizens of Norfolk in a cost effective manner. This research project employed an evaluative research methodology to answer the following questions:

1. How have the new fire apparatus purchased between Fiscal Years 1995 and 1997 impacted the NFPS?

2. What is the opinion of NFPS personnel on the performance of the new fire apparatus purchased by the department between Fiscal Years 1995 and 1997?

3. What is the opinion of personnel from other career fire departments on the performance of new fire apparatus of similar make and models to that purchased by the NFPS?

The procedures used to complete this research included a literature review of fire service journals, magazines, and textbooks, a review of Norfolk City documents and records, an opinion survey of NFPS personnel assigned to new fire apparatus, and an opinion survey of personnel from other career fire departments that have purchased similar make and models of fire apparatus.

## Background and Significance

The NFPS was formed in April 1991, by the merger of the Norfolk Fire Department (NFD) and the Bureau of Paramedical Rescue Services (BPRS). This merger followed a two-year study that was initiated by city management to find the most cost effective alternative for meeting the rapidly growing demands on the city's emergency medical service, without reducing the existing level of fire protection (Fire and Emergency Medical Steering Committee, 1990). Between 1991 and 1993, all former BPRS personnel received cross-training to serve as firefighters, and qualified NFD personnel received cross-training for emergency medical service duties. During Fiscal Year 1992, the city's compensation plan was amended to include the job classifications of firefighter/paramedic, firefighter/cardiac technician, and firefighter/shock-trauma technician. The city's civil service regulations were also amended, requiring all personnel hired by the NFPS after July 1, 1991 to be cross-trained for both firefighting and emergency medical service duties.

The NFPS provides fire protection, fire prevention, emergency medical care, technical rescue, and hazardous materials response services to a 62 square mile city with a population of 235,911 residents. During 1997, the department answered 54,411 emergency calls. The NFPS currently employees 491 personnel, and is comprised of an operations bureau, a fire prevention bureau, and a training bureau.

The operations bureau consists of 3 battalions, 15 fire stations, 14 engine companies, 7 ladder companies, 2 squad companies, and 10 rescue units. The duty schedule for the operations bureau consists of a 24-hour shift, and a 53-hour work week. Personnel who are cross-trained for both

firefighting and emergency medical duties serve a 12-hour rotation between a fire company and a rescue unit during each 24-hour shift (NFPS, 1997).

With the implementation of the merger, the function of the department's fire apparatus changed dramatically. Between 1991 and 1993, all engine companies and squad companies were stocked with additional emergency medical equipment including defibrillators, respiratory therapy devices, spinal immobilization devices, and drug boxes. Ten of the engine companies were licensed by the Virginia Department of Health as advanced life support (ALS) units. In addition, the department expanded the existing hazardous materials response program and initiated technical rescue services. As a result, both squad companies were furnished with additional specialty equipment. Unfortunately, it soon became evident that many of the engine companies and one of the squad companies were not designed to accommodate these additional equipment loads.

Many of the department's fire apparatus had been purchased during the 1960s and 1970s, and were designed to carry only limited firefighting equipment. As a result, the combined weight of the additional equipment in some cases exceeded gross vehicle weight ratings, causing reduced brake performance and increased stress on chassis frames and suspension systems.

The need for increased equipment storage capacity was not the only fire apparatus dilemma facing NFPS administrators. Prior to 1988, the NFD closely followed a replacement cycle that permitted the purchase of a new pumper every one to two years, and a new aerial ladder every four to six years. This practice was funded through the firefighting equipment account of the NFD's annual operating budget. During the late 1980s, a series of budget reductions mandated by city management

forced NFD administrators to eliminate apparatus funding from the operating budget. Without a regular replacement program, the average age of the fire apparatus fleet increased and the condition of various units declined into a state of disrepair. This problem was compounded by a serious motor vehicle accident in 1989 that seriously damaged one first-line engine company.

Coinciding with the merger, former NFD administrators were successful in negotiating emergency funding for the immediate purchase of four new pumpers. Special revenue sources provided additional funding for the purchase of a heavy rescue vehicle to replace a step-van that had been used as a squad company. Unfortunately, the purchase of this apparatus proved to be only a short-term improvement, as the condition of the fleet continued to regress over the next several years in the absence of a regular replacement program (NFPS, 1993). By 1993, the average age of apparatus in the NFPS fleet had increased to 15.8 years. Thirty-eight percent of the fleet was more than 20 years of age, with some apparatus ranging 5 to 10 years beyond the maximum service-life recommended by the National Fire Protection Association. The average age of the various types of first-line apparatus was 11.1 years for engine companies, 18.1 years for ladder companies, and 6.5 years for squad companies.

Many firefighters complained that firefighting equipment had become unreliable, and cited examples of equipment failures during emergency incidents. Furthermore, the city's fleet manager reported an increase in maintenance costs due to the age of the fleet, and a shortage of replacement parts for those vehicles that were more than 20 years of age. Troubled by the deteriorating condition of the department's fire apparatus and an apparent lack of political and financial support for a planned replacement program, members of the Norfolk Professional Firefighters Association (NPFF), Local 68

of the International Association of Firefighters (IAFF), initiated a public education program that increased the political pressure on elected officials to provide funding for fire apparatus replacement (Senter, 1997).

In response to the NPFF's campaign and a series of investigative news reports on the state of the NFPS emergency vehicle fleet, the Norfolk City Council directed the city manager to investigate the problem and take corrective action. In July 1993, the assistant city manager for public safety established a task force to survey the existing NFPS fleet, identify vehicle requirements to meet the mission of the department, and recommend a manageable replacement schedule. The task force included several NFPS officers, the city's fleet manager, and a representative from the finance department. The efforts of task force members culminated in a comprehensive vehicle study that consisted of an assessment of the condition of existing fire apparatus, a survey of fire apparatus replacement programs in surrounding jurisdictions, and a proposed apparatus replacement schedule (G. C. Crawley, personal communication, July 27, 1993). After careful review of the study and the proposed replacement schedule, the city manager approved the use of master lease financing to fund a multi-year fire apparatus replacement program beginning in Fiscal Year 1995 (D. L. Burcham, personal communication, December 29, 1993). The intent of this program was to provide for the replacement of engine and ladder companies every 15 years and the replacement of squad companies every 10 years.

Immediately following the commitment of city management to replace aging fire apparatus, the NFPS formed a committee to develop bid specifications for the pending purchases. This committee was comprised of officers and firefighters who operated the department's fire apparatus on a daily

basis, and a representative from the city's fleet maintenance facility. Committee members sought the input of both administrators and line personnel in identifying existing and future service demands, and establishing the minimum design criteria for each type of apparatus. In addition, the products of many fire apparatus manufacturers were evaluated at trade shows, and several fire equipment vendors provided vehicles for field testing on the city's streets. Within six months a comprehensive set of bid specifications was developed and released to the purchasing agent. These specifications included many design changes that were aimed at meeting both the existing and future apparatus requirements of the department. The changes included enhanced firefighter safety features, increased equipment storage space, "roll-up" compartment doors, heavy-duty aerial devices, on-board electrical generators, and 110-volt scene lighting systems (J. N. Applewhite, personal communication, April 20, 1998).

The bid process for the first apparatus purchased in accordance with the new apparatus designs was conducted between August and September 1994. Fire equipment vendors were invited to bid on two rescue pumpers, one rear-mount aerial platform, and one heavy rescue vehicle. A total of 14 bid proposals from 7 different vendors were received. Bid prices ranged between $ 272,924.00 and $ 313,392.00 for the rescue pumpers, between $ 501,559.00 and $ 588,017.00 for the aerial platform, and between $ 341,220.00 and $ 428,884 for the heavy rescue vehicle. Following a comprehensive evaluation of all bid proposals, the entire bid was awarded to a single vendor at a price of $ 1,515,520.00 (R. T. Wakeham, personal communication, October 20, 1998). Construction began in early December and the completed apparatus were delivered to the department during June and July 1995.

The response of firefighters to the new apparatus consisted of mixed emotions. Although everyone welcomed the arrival of new equipment, many firefighters considered the changes in engine and ladder company designs too radical. The incorporation of rescue-style body compartments on the engine companies necessitated an increase in hose and ground ladder storage heights, which triggered a series of complaints from firefighters about potential equipment accessibility problems and safety hazards. Various concerns were also raised about the larger size of the new ladder companies and the maneuverability problems that would likely be encountered on narrow city streets. To further compound negative opinions, a series of warranty problems plagued the new apparatus during its first year of operation. Malfunctions occurred within the electrical systems of each apparatus, prompting repeated service calls. In addition, stress cracks developed in the bodies of both rescue pumpers, which ultimately required the shipment of the vehicles back to the factory for repair. Although the vendor and manufacturer worked diligently to correct these problems, numerous firefighters considered the new apparatus to be unreliable and expressed concerns about its potential service longevity (J. N. Applewhite, personal communication, April 20, 1998).

Additional apparatus were purchased by the NFPS through separate bid processes during Fiscal Years 1996 and 1997. The 1996 bid included specifications for three rescue pumpers and two rear-mount aerial ladders. Bid proposals were submitted by three equipment vendors and included pricing that ranged between $ 288,142.00 and $ 335,349.00 for the rescue pumpers and between $ 449,412.00 and $ 544,664.00 for the aerial ladders. The 1997 bid included specifications for two rescue pumpers and one rear-mount aerial platform. Bid proposals were submitted by two equipment

vendors and included pricing that ranged between $ 319,967 and $ 345,556.00 for the rescue pumpers and between $ 573,477.00 and $ 627,745.00 for the aerial platform. The vendor who filled the Fiscal Year 1995 order was also awarded the bids for 1996 and 1997, at the prices of $ 2,095,375.00 and $ 1,318,857.00 respectively (D. A. Haupt, personal communication, September 10, 1997; R. T. Wakeham, personal communication, February 15, 1996). The 1996 order was received during January 1997, and the department expects to accept delivery of the 1997 order by August 1998. As additional units were placed in service, firefighters began accepting many of the apparatus design changes. However, some of the same complaints that originated with the first apparatus order are still being voiced today (J. N. Applewhite, personal communication, April 20, 1998).

This research project was completed in accordance with the applied research requirements of the National Fire Academy's Executive Fire Officer Program. The problem addressed by this research project related specifically to Phase IV: Evaluation/Institutionalism of the Change Management Model, as presented in the Strategic Management of Change course. This phase of the model was designed to guide administrators in the evaluation of change initiatives in an organization. It was anticipated that the recommendations formulated to improve the design of future fire apparatus purchased by the NFPS, would also be useful to other municipal fire departments planning for the replacement of fire apparatus.

## Literature Review

A literature review was performed to identify existing research on the factors that affect fire apparatus design, and practical models for evaluating fire apparatus design changes. The literature review involved a search of fire service trade journals, magazines, and textbooks. Those sources found to be relevant to this research project were summarized and included in this report.

### Regulations and Standards Influencing Fire Apparatus Design

The literature review revealed federal regulations, fire service consensus standards, and a fire insurance standard that have all influenced the design of modern fire apparatus. The federal standards included those requirements mandated by the National Traffic and Motor Vehicle Safety Act and the Clean Air Act. The fire service consensus standards consisted of National Fire Protection Association (NFPA) Standards 1201, 1500, and 1901. The fire insurance standard was that of the Insurance Services Office (ISO). It was also discovered that the Commission on Fire Accreditation International (CFAI), a joint endeavor by the International Association of Fire Chiefs (IAFC) and the International City Management Association (ICMA), included references to fire apparatus design and procurement processes in their assessment manual.

#### Federal regulations.

The National Traffic and Motor Vehicle Safety Act of 1966, mandated that all manufacturers adhere to specific safety standards when designing and constructing motor vehicles. These standards are frequently updated and fire apparatus must be constructed to conform to the standards in effect at the time the purchase contract is signed. Another piece of federal legislation that has affected fire

apparatus design is the Clean Air Act. It was suggested that the emission control standards mandated by this legislation have impacted engine performance in recent years and greatly influenced the incorporation of electronic controls on diesel engines (NFPA, 1990).

**Fire service consensus standards.**

National Fire Protection Association Standard 1201, entitled "Developing Fire Protection Services for the Public" (1994), included several sections in Chapter 17: Equipment and Buildings, that addressed the procurement and maintenance of fire apparatus. These sections required (a) appropriate inventory control of all fire apparatus and equipment owned and operated by a fire department, (b) implementation of appropriate forecasting methods to project apparatus service-life expectancies and replacement needs, (c) development of written fire apparatus bid specifications in accordance with all applicable NFPA standards, (d) implementation of routine inspection and preventive maintenance programs for fire apparatus, and (e) implementation of service testing for fire pumpers and aerial devices in accordance with NFPA 1901, 1911 and 1914.

National Fire Protection Association Standard 1500, entitled "Fire Department Occupational Safety and Health Program" (1992), included a chapter that focused on various fire apparatus safety issues. Chapter 4: Vehicles and Equipment, addressed (a) fire apparatus design requirements, (b) training and certification of fire apparatus operators, (c) safe driving and operating practices for fire apparatus, (d) safety practices for firefighters riding fire apparatus, and (e) regular inspection and preventive maintenance and repair of fire apparatus.

National Fire Protection Association Standard 1901, entitled "Standard for Automotive Fire Apparatus" (1996), was comprised of numerous chapters that outlined the design requirements for (a) pumper fire apparatus; (b) initial attack fire apparatus; (c) mobile water supply fire apparatus; (d) aerial fire apparatus; (e) special service fire apparatus; (f) chassis and vehicle components; (g) low voltage electrical systems and warning devices; (h) driving and crew areas; (i) body, compartments, and equipment mounting; (j) fire pump and associated equipment; (k) water transfer pump and associated equipment; (l) water tanks; (m) aerial devices; (n) foam proportioning systems; (o) compressed air foam systems; (p) line voltage electrical system; (q) command and communications; (r) air systems; (s) winches; and (t) referenced publications. One author (Peters, 1996) wrote that this document has influenced the design requirements of new fire apparatus more so than any other single standard. Since 1914 the standard has undergone numerous revisions, and one of the most extensive revisions took effect in 1996. It was noted that the impact of this revision on fire apparatus design will likely continue for many years.

**Fire insurance standards.**

The works of several authors (Perry, 1995; Tricarico, 1997) outlined the role of the ISO in shaping fire apparatus design. The ISO routinely rates the capabilities of local fire departments to respond to and suppress fires in their communities. The ISO follows the Fire Suppression Rating Schedule (FSRS) to rate the fire defenses of a community according to the criteria of fire flow capabilities, fire department resources, and available water supply. Fire departments are classified by the ISO on a scale of 1 (highest) to 10 (lowest), based on the ratings received for each criterion.

Insurance underwriters often base fire insurance rates in a given community on the ISO class of the local fire department.

Requirements for fire apparatus were addressed by the fire department resources criterion. Based on the results of Basic Fire Flow (BFF) calculations, a minimum number of engine companies and pump capacities are established to meet estimated fire suppression requirements. Also, depending on the total number of buildings that are at least 3 stories or 35 feet in height, the need for ladder or service companies may be established. Furthermore, the ISO requires that at least one piece of fire apparatus in a fire department's fleet must conform to NFPA 1901.

**Fire service accreditation system.**

A review of the CFAI assessment manual, revealed much information about the joint efforts of the ICMA and the IAFC, in the development of a voluntary accreditation system for local fire departments. The purpose of this accreditation system was to "assist agencies in becoming goal-oriented, forward-looking, well-organized, and properly equipped and trained, and provide a methodology for continually evaluating and improving services" (Bruegman & Coleman, 1997, p. 84). The system evaluates a fire department according to 10 categories: governance and administration, assessment and planning, goals and objectives, financial resources, programs, physical resources, human resources, training and competency, essential resources, and external system relationships.

The CFAI (1997) addressed fire apparatus requirements in Category VI: Physical Resources. In accordance with Criterion 6B, "apparatus and resources are designed and purchased to be adequate to meet the agency's goals and objectives" (p. 20). Rating for this criterion is based on the

performance indicators of (a) apparatus location in accordance with established standards of coverage for the community, (b) appropriateness of apparatus types for services provided, (c) existence of an apparatus replacement schedule, and (d) existence of a program for writing apparatus replacement specifications.

## Fire Apparatus Design Considerations

In 1985, Szytkeil wrote about the demands placed on fire apparatus and suggested that they differ greatly from those placed on general industry vehicles. Fire apparatus are subjected to extreme operating conditions including rapid acceleration and deceleration, and high engine speeds for extended periods of time. In addition, fire apparatus are constantly stressed by dynamic loads in the form of equipment, hose, water, and aerial devices. Therefore, it was recommended that all components of a fire apparatus be carefully designed to meet the daily demands to which they are exposed.

The NFPA (1990) stressed the importance of careful planning when designing new fire apparatus. It was recommended that the planning process include the examination of a fire department's individual needs, and the solicitation of input from other fire departments that have recently purchased fire apparatus. Consultation with the authority governing local fire insurance rates for specific fire apparatus requirements was also recommended. Furthermore, Peters (1996) discussed the need to assess the emergency services needs of the community as part of the planning process for new fire apparatus.

Liebson (1985) described a three-step process for designing fire apparatus that involves assigning weighted ratings to specific criterion to which a fire apparatus in a given community must

conform. The steps involved in this process consisted of (a) identifying fire department needs, (b) collecting and analyzing apparatus performance information and assigning weighted ratings on a scale of 1-10, and (c) ranking fire department needs and performance requirements in order of importance.

Frietag (1985) noted that when designing new fire apparatus, fire department personnel should draw from their experiences with local operating conditions and past apparatus purchases, and the performance of existing units.

Various authors (Brennan, 1996; Frietag, 1985; Jakubowski, 1993) agreed that the involvement of fire department personnel in the apparatus design process is extremely important. Personnel should be asked to rate their level of satisfaction or dissatisfaction with existing apparatus and make suggestions for improving the designs of future purchases. It was suggested that personnel involvement is useful for gaining new or potentially cost-saving ideas and may help soften firefighter resistance to fire apparatus design changes.

Jakubowski (1993) stressed the importance of having an established mission for a given piece of apparatus before initiating the design process. This mission must give a clear picture of the type of services the vehicle will provide and the type and quantity of equipment the vehicle will carry. Craven (1995) noted that a clear fire apparatus mission and design objectives are needed to help fire departments ensure that construction costs stay within budget projections.

Several authors (Carlson, 1995; Cottet, 1996) suggested that fire departments should be innovative in apparatus design, and should avoid the temptation to copy without exception a design used by other fire departments. Carlson (1995) suggested various apparatus innovations that could help fire

departments better meet multiple missions in a more cost effective manner: (a) purchase small, fast attack units to respond on emergency medical and service calls, holding conventional pumpers in reserve for fires; (b) purchase a medium-sized initial attack unit equipped with a 750 gpm pump to respond to all emergency calls, and dispatch additional personnel assigned to quints or conventional pumpers on fires and large scale emergencies; (c) purchase an entire fleet of quints and equip each unit with the capability to serve as either an engine or ladder company; (d) purchase ladders and squads with a booster pump and tank to allow personnel to attack a fire when arriving on a fire scene prior to the arrival of an engine company; (e) purchase a combination ambulance and initial attack unit or furnish pumpers with transport capabilities; (f) include Class A foam systems on pumpers; and (g) purchase a rescue pumper and equip the unit for multiple missions such as fire suppression, emergency medical care, and technical rescue.

Despite the need to be innovative, various authors (Brennan, 1996; Carlson, 1995; Cottett, 1996; Craven, 1995) cautioned that any apparatus design must also be practical. Apparatus must not be overly complicated to operate, and equipment must be stored in an appropriate location that will allow safe and easy retrieval by personnel. In addition, Carlson (1995) noted that mechanical components must be easily accessible to maintenance personnel so that apparatus down-time will be minimized. By thinking creatively, fire departments can design an innovative fire apparatus that will meet these requirements without a corresponding increase in the overall size of the vehicle. The goal of fire apparatus design should be to "increase utilization and functionality, not to prove that bigger is better" (p. 59).

Craven and Steffens (1996) stressed the importance of incorporating safety into the design of fire apparatus, and noted that construction deficiencies have contributed to past aerial ladder failures. Craven (1994) focused additional attention on fire apparatus safety issues presented by the fire services' need to carry more and varied types of equipment, and the subsequent introduction of larger and correspondingly heavier fire apparatus. It was noted that although overall firefighter mortality rates have decreased on the fireground, approximately 25% of all firefighter deaths still occur while responding to or returning from alarms. It was theorized that as gross vehicle weights continue to increase, the ability to safely maneuver and stop fire apparatus will be diminished, thereby decreasing the likelihood that such deaths will be significantly reduced in the future.

## Fire Apparatus Design of the Future

In one fire service article, Simmons (1998) summarized the outcome of a formal round table discussion between various fire chiefs on the future of fire apparatus, that was sponsored by the Fire Apparatus Manufacturer's Association (FAMA) during its Fall 1997 meeting in Tucson, Arizona. The participants in the discussion made various conclusions about existing and future challenges that should be addressed by fire apparatus designs: (a) Firefighter satisfaction with a piece of fire apparatus is often based on how comfortable firefighters are in the cab and crew cab areas, (b) it is becoming increasingly important for fire departments to provide fire apparatus that allow the rehabilitation of firefighters at fire scenes, (c) the size of fire apparatus pump panels needs to be reduced, (d) fire apparatus design is shaped by the service demands in the community it will serve, (e) the role of the fire service in many communities is changing from a technical emergency services provider to that of a human services

provider, (f) due to varied demands, it is not possible to design a fire apparatus that will meet the needs of all communities, (g) many fire departments are faced with different problems that affect the purchase of fire apparatus such as downsizing and reduced funding, (h) large, sophisticated fire apparatus are not cost effective to operate, (i) there is a distinct need for smaller apparatus for EMS responses; (j) the fire service must work to influence the fire protection requirements as dictated by the Insurance Services Office, (k) fire apparatus design is being impacted by emergency medical service needs, and (l) the realities of urban violence and terrorism have signaled the need for fire apparatus that can be locked, thereby securing equipment. The content of the discussion was further characterized by useful suggestions offered to the fire apparatus industry: (a) Fire apparatus should be designed to meet a specified mission, (b) individual fire apparatus must be specifically designed to meet the needs of a given community, (c) the dynamics of local politics impacts fire apparatus procurement, (d) fire apparatus must be designed so that it is easy to operate, (e) manufacturers should strive to be innovative in fire apparatus design, (f) manufacturers must remember the importance of fire department personnel when designing fire apparatus, and (g) fire departments would benefit tremendously from training on specification writing.

Adams (1996) discussed the future of fire apparatus in the United States and concluded that although numerous advances have been made in apparatus design, the U.S. fire service has performed poorly at packaging the new technology so that firefighter safety and practicality are ensured. The need to design fire apparatus based on personnel needs and safety requirements was stressed. It was also

noted that emergency vehicles of the future should not be overly complicated to operate and personnel must have easy access to all equipment storage areas.

**Literature Review Summary**

The literature review provided key insights into various factors that affect the design of fire apparatus. These factors included regulations and standards, service demands, personnel requirements, mission requirements, innovations, and future challenges.

It was discovered that numerous federal regulations, fire service consensus standards, and a fire insurance standard directly influence fire apparatus design. The research of one author (Peters, 1996) also showed that additional safety and performance features mandated by recent changes in NFPA 1901 have increased the purchase price of fire apparatus. Depending on the manufacturer and the options specified, it was estimated that fire departments can expect to pay between $ 5,500.00 to $ 20,500.00 more for apparatus purchased after August 1, 1996.

It was suggested that the demands placed on fire apparatus are much greater than those placed on general industry vehicles. Consequently, it was recommended that fire apparatus be carefully designed to withstand extreme operating conditions in a safe and effective manner.

The direct involvement of firefighters in the design process was stressed as an important factor in developing innovative, practical, and cost-effective alternatives. It was suggested that firefighter involvement can also improve the acceptance of apparatus design changes within a fire department.

The development of specific mission statements for fire apparatus was viewed as an essential component of any design process. It was recommended that the mission statement include a definition of the services to be provided and associated equipment requirements.

Innovation was regarded as a valuable attribute to the apparatus design process. Conversely, it was recognized that some apparatus innovations often create obstacles which negatively impact personnel performance at incident scenes. Therefore, it was noted that any innovation should also be practical.

It was theorized that fire apparatus designs of the future will be closely shaped by the types of emergency services provided by the fire service and the needs of firefighting personnel. Much emphasis was placed on the need to incorporate simplicity in all future apparatus designs.

Despite a wealth of information on fire apparatus design, specification, and procurement processes, a search of available fire service literature did not produce any examples of practical methods for evaluating fire apparatus design changes.

The findings of the authors summarized in the literature review and the lack of a practical evaluation model for assessing fire apparatus design changes, influenced the decision to perform additional research. The purpose of the additional research was to substantiate the findings of others, add to the body of knowledge on fire apparatus design considerations, evaluate the effectiveness of apparatus design changes in the NFPS, and strengthen the recommendations made in this report.

## Procedures

This research project employed evaluative research methodologies to examine fire apparatus design considerations, assess design changes in the NFPS, and identify the steps that should be taken by the NFPS to improve the design of future apparatus. The procedures used to complete this research included a literature review of fire service journals, magazines and textbooks, a review of Norfolk City documents and records, an opinion survey of NFPS personnel assigned to new fire apparatus, and an opinion survey of personnel from other career fire departments that have purchased similar make and models of fire apparatus. The identities of the fire apparatus manufacturer and fire equipment vendor, who were responsible for the construction and delivery of new apparatus purchased by the NFPS and the other fire departments that were surveyed, were not revealed in this report. This action was taken to avoid the appearance of endorsement or denunciation of a particular brand of fire apparatus by the NFPS or the City of Norfolk.

### Literature Review

The literature review was initiated at the National Fire Academy's Learning Resource Center (LRC) during January 1998. Subsequent materials were supplied by the LRC through the U. S. Postal Service and the Interlibrary Loan Program (ILL). Additional literature reviews were conducted at the Virginia Beach Fire Department Training Center Library in Virginia Beach, Virginia, and the author's personal library between February and April 1998.

The literature review targeted trade journals, magazines, and textbooks that contained information on fire apparatus design considerations and evaluation models for assessing fire apparatus

design changes. Applicable sources were summarized and included in the Literature Review section of this report.

**Review of Norfolk City Documents and Records**

A comprehensive review of Norfolk City documents and records was conducted between April and May 1998 to assess the impact of new apparatus purchases on the NFPS, based on the apparatus requirements established in the NFPS Vehicle Study (1993). These requirements included (a) increased safety factors to protect firefighting personnel and the general public, (b) consistent performance under the rigors of repeated emergency responses with a minimal amount of down time, (c) increased equipment storage capabilities, and (d) cost effective operation. From these requirements, outcome measures were established to gauge the effects of new apparatus purchases on the NFPS. The outcome measures consisted of safety improvements, average age, average mileage, apparatus down-time, equipment storage space, apparatus pricing, and average maintenance costs.

Target data pertaining to the average age, mileage and maintenance costs were obtained from the NFPS Vehicle Study and Norfolk Fleet Maintenance records for Fiscal Year 1997. Data pertaining to safety improvements and equipment storage space were obtained from NFPS fire apparatus bid specifications and an assessment of existing storage capacity on apparatus purchased prior to Fiscal Year 1995. Apparatus pricing information was obtained from purchase orders issued by the Norfolk City Purchasing Department. Estimates of apparatus down-time were obtained from Norfolk Fleet Maintenance records.

**NFPS User Surveys**

Opinion surveys were developed to assess the overall satisfaction of NFPS personnel with the performance of new apparatus purchased by the department between Fiscal Years 1995 and 1997.

The surveys were drafted with the assistance of the personnel assigned to Engines 1 and 2, Ladder 1, and Squad 1 B-shift. These personnel suggested various criteria that should be addressed in the evaluation of fire apparatus design changes. Although all apparatus had similar features, there were distinct differences in the specialized and ancillary equipment furnished on engine, ladder, and squad companies. Therefore, specific surveys were developed for each apparatus type.

The surveys asked personnel to rate various apparatus performance criteria on a scale of 1 (poor) to 5 (excellent). Each survey was designed to assess (a) apparatus operational performance criteria including maneuverability, vehicle handling characteristics, vehicle acceleration performance, vehicle braking performance, ergonomics, driver visibility, and ease of routine maintenance; (b) personnel accommodation criteria including seating configuration, available space for driver and officer positions, available space for firefighter riding positions, and the David-Clark communications system; (c) equipment storage criteria including the amount of compartment space, accessibility to equipment stored in compartments, and the effectiveness of roll-up compartment doors, and (d) ancillary equipment performance criteria including electrical generator performance, ease of generator operation, and performance of electric cables and cable storage reels. In addition, each survey asked personnel if the piece of apparatus met current mission requirements of the NFPS and allowed flexibility in meeting possible changes in mission requirements over the next ten years. Personnel were also asked if the

NFPS should continue to include roll-up style exterior compartment doors as a design specification for future apparatus purchases. Furthermore, personnel were offered the opportunity to list suggestions for improving the design of future apparatus.

The engine company survey was designed to assess additional criteria that was relevant to a fire pumper: (a) equipment storage criteria including the configuration of hosebeds, accessibility to hose stored in hosebeds, and accessibility to hard suction and ground ladders; and (b) fire pump performance criteria including the overall performance of the fire pump, ease of fire pump operation, the overall performance of the foam proportioning system, and ease of foam proportioning system operation. Personnel were also asked if foam proportioning systems, booster hose reels, and electrical generators should continue to be included as design specifications for future engine company purchases.

The ladder company survey was designed to assess additional criteria that was relevant to an aerial ladder including the overall performance of the aerial device, ease of aerial device operation, overall performance of the outrigger system, ease of outrigger system operation, and ease of preventive maintenance on the aerial device. Personnel were asked if they routinely utilized the "level-assist" feature when setting the outriggers for aerial operation. Personnel were also asked if the NFPS should include provisions in the design of future ladder companies to allow the storage of ground ladders that are 40 to 50 feet in length.

The squad company survey was designed to assess additional criteria that was relevant to a heavy rescue vehicle: (a) equipment storage criteria including accessibility to rooftop compartments; (b) SCBA air compressor/fill station performance criteria including overall performance, ease of air

compressor/fill station maintenance, and ease of routine maintenance checks; and (c) ancillary equipment performance criteria including the performance of the light tower, performance of air systems and storage reels, and performance of the on-board Hurst system and reels. Personnel were asked if a "non-walk-in" style body provided more equipment storage space than a "walk-in" style body, if mobile air compressors should continue to be design specifications for future squad company purchases. Personnel were also asked if "beverage delivery" style body designs should be considered for future squad purchases.

Draft copies of the surveys were field tested by several firefighters assigned to the 1st Battalion B-shift. The surveys were edited as needed, and final copies were prepared for delivery. A total of 162 surveys were distributed through inter-departmental mail during May 1997 to NFPS personnel assigned to the fire apparatus purchased between Fiscal Years 1995 and 1997. One hundred twenty-two surveys were completed and returned, which accounted for a 75% response rate.

The raw data obtained from the NFPS user surveys were arranged in a frequency distribution and examined for patterns of dispersion and central tendency. Mean scores were then calculated to attain average ratings for each of the design and performance criterion.

**Fire Apparatus Program Manager and User Surveys of Other Fire Departments**

Opinion surveys were also developed and mailed to other career fire departments that purchased fire apparatus of similar make and models to that purchased by the NFPS during the same time period. A fire apparatus program manager survey was developed to obtain comparative data relating to purchase price, apparatus performance, apparatus quality, warranty service, and overall

customer satisfaction with the manufacturer's product. The user surveys were developed in the same manner as the NFPS user surveys, and addressed much of the same design and performance criteria. The purpose of the additional user surveys was to gauge the differences in opinion between NFPS personnel and personnel from other departments on the performance of similar fire apparatus.

The fire equipment vendor that filled the NFPS fire apparatus orders between Fiscal Years 1995 and 1997, provided a list of fire departments that purchased similar apparatus during the same time period. Thirteen career fire departments were selected from the list and asked to participate in the survey. A total of 13 fire apparatus program manager surveys and 42 user surveys were mailed to these departments in late April 1998. Five program manager surveys and 15 user surveys were completed and returned by the June 10, 1998 deadline, which accounted for response rates of 38.5% and 35.7% respectively. Included were 11 completed surveys for engine companies and three completed surveys for ladder companies. Unfortunately, no completed user surveys for squad companies were received. The fire departments that participated in the survey included (a) Mobile, Alabama; (b) Aurora, Colorado; (c) Lynn, Massachusetts; (d) Charleston, South Carolina; and (e) Chesapeake, Virginia.

The results of the program manager and user surveys of other carer fire departments that purchased similar make and models of apparatus were analyzed, calculated and reported in the same manner as the NFPS user surveys.

**Assumptions**

The procedures used to complete this research project were based on four basic assumptions. First, it was assumed that all authors cited in the literature review performed objective and unbiased research. Second, it was assumed that all Norfolk City documents and records were accurate and current. Third, it was assumed that each survey respondent answered all questions fairly and objectively. Fourth, it was assumed that survey respondents did not discuss apparatus performance criteria with each other prior to completing the surveys.

**Limitations**

The limitations that affected this research project included time, ambiguous program goals and apparatus requirements, impact assessment limitations, research design and statistical analysis, and selection methods for survey participants outside the NFPS.

The six-month time limit imposed by the National Fire Academy for the completion of Executive Fire Officer applied research projects, did not allow a more thorough review of available literature nor did it allow sufficient time for the completion and return of out-of-state surveys.

The goals of the NFPS multi-year fire apparatus replacement program and corresponding apparatus requirements, were ambiguous and lacked quantifiable objectives. This reduced the accuracy of all outcome measures used to assess the net effects of new apparatus purchases on the NFPS.

The fire apparatus purchased during Fiscal Year 1997, including two rescue pumpers and one rear-mount aerial platform, had not been delivered to the NFPS as of the writing of this report. Therefore, the assessment of the full impact of this apparatus on the NFPS was not possible. When this

apparatus is delivered and placed in service, the average age and mileage of first-line engine and ladder companies will be further reduced.

The assessment of the full impact of the new apparatus on maintenance costs of first-line apparatus was limited by the fact that three engine companies and two ladder companies are still covered by manufacturers' warranties. Therefore, some repairs that would normally be charged to the NFPS vehicle maintenance account were being covered by the fire equipment vendor at no cost to the city. A true assessment of the impact on maintenance costs will not be possible until all warranties have expired.

The use of a simple before-and-after research design in assessing changes in the NFPS fleet did not eliminate the possibility that variables other than the new apparatus may have affected the net outcomes. In addition, the use of the arithmetic mean as a measure of central tendency did not control the effects of extreme responses.

Due to the limited number of career fire departments purchasing similar make and models of fire apparatus during the same time periods as that purchased by the NFPS, randomization was not employed in the selection of potential survey participants. Therefore, the results of this survey cannot be considered with any degree of certainty to be representative of the entire population of fire departments that purchased similar make and models of fire apparatus.

## Results

**1. How have the new fire apparatus purchased between Fiscal Years 1995 and 1997 impacted the NFPS?**

### Safety Improvements

A review of the NFPS bid specifications for all fire apparatus purchased between Fiscal Years 1995 and 1997 revealed numerous safety improvements that were afforded by the new apparatus designs. These safety features included (a) full compliance with NFPA 1901, (b) full compliance with federal motor vehicle safety standards, (c) a "roll-cage" in the cab roof assemblies, (d) fully enclosed and air conditioned cabs, (e) three-point seat belt harnesses, (f) communications headsets, (g) disk brakes, (h) secondary braking devices, (I) improved emergency lighting and scene lighting packages, and (j) 500 pound minimum tip-load ratings for aerial ladders.

### Average Age

A comparative analysis of the apparatus data in the 1993 NFPS Vehicle Study and the Norfolk Fleet Maintenance records for Fiscal Year 1997, showed a 19% decrease in the average age of fire apparatus in the NFPS fleet from 15.8 years to 12.8 years, following the purchase of the new apparatus. As illustrated in Figure B1, specific changes in the average ages of first-line fire apparatus were noted: (a) engine companies--down 34.6% from 11.1 years to 7.3 years; (b) ladder companies--down 37.8% from 18.1 years to 11.3 years; and (c) squad companies--down 38.5% from 6.5 years to 4 years. As illustrated in Figure B2, specific changes in the average ages of reserve apparatus were noted: (a) engine companies--up 8.1% from 22.7 years to 24.5 years; (b) ladder companies--down

10.2% from 29.5 years to 26.5 years; and (c) squad companies--up 23.1% from 13.0 years to 16.0 years.

**Average Mileage**

A comparative analysis of the apparatus data in the 1993 NFPS Vehicle Study and the Norfolk Fleet Maintenance records for Fiscal Year 1997, showed a 15.1% decrease in the average mileage of fire apparatus in the NFPS fleet from 81,370.8 to 69,080.7 miles, following the purchase of the new apparatus. As illustrated in Figure B3, specific changes in the average mileage of first-line apparatus were noted: (a) engine companies--down 39% from 68,674.1 to 41,872.0 miles; (b) ladder companies--down 41% from 72,404.1 to 42,702.1 miles; and (c) squad companies--up 13.0% from 73,835.0 to 83,449.0 miles. As illustrated in Figure B4, specific changes in the average mileage of reserve apparatus were noted: (a) engine companies--up 13.1% from 113,973.0 to 128,894.7 miles; (b) ladder companies--down 9.7% from 91,108.0 to 82,279.5 miles; and (c) squad companies--up 18.9% from 121,877.0 to 144,857.0 miles.

**Apparatus Down-Time**

It was discovered that Norfolk Fleet Maintenance did not track down-time for new or existing fire apparatus, which limited the evaluation of apparatus reliability. Fleet maintenance did however track reported warranty problems on new apparatus which was helpful in evaluating reliability.

A review of Norfolk Fleet Maintenance records on all fire apparatus purchased between Fiscal Years 1995 and 1997 revealed a total of 123 problems that had been reported to the equipment vendor for resolution under the conditions of the manufacturer's warranty. As shown in Table C1, these

warranty problems involved 11 different areas of the apparatus including (a) electrical system--43.9% of all reported problems; (b) body/cab components--13% of all reported problems; (c) defects in metal or welds--8.9% of all reported problems; (d) engine--6.5% of all reported problems; (e) ancillary equipment--6.5% of all reported problems; (f) aerial/outrigger system--4.9% of all reported problems; (g) brake system--4.9% of all reported problems; (h) fire pump--4.1% of all reported problems; (i) compartment doors--4.1% of all reported problems; (j) transmission--1.6% of all reported problems; and (k) suspension--1.6% of all reported problems.

Records of reported warranty problems on fire apparatus purchased prior to Fiscal Year 1995 were unavailable, and thus prohibited any comparative analysis of the reliability of old and new apparatus designs.

**Equipment Storage Space**

An analysis of the NFPS bid specifications for all fire apparatus purchased between Fiscal Years 1995 and 1997 revealed a marked increase in available compartment space over previous apparatus designs. As shown in Table C2, the new apparatus designs provided approximately 141.7 cubic feet of compartment space for engine companies, between 316.2 and 324.3 cubic feet of compartment space for ladder companies, and 541.7 cubic feet of compartment space for squad companies.

The volume of available compartment space on 1970s and 1980s era apparatus was calculated and compared to that of the new apparatus. As shown in Table C2, increases in available compartment space were noted: (a) engine companies--increased equipment storage capacity that ranged between

28.1% and 164.9%, (b) ladder companies--increased equipment storage capacity that ranged between 29.6% and 163.1%; and (c) squad companies--14.1% increase in equipment storage capacity.

The volume of available hosebed storage space on 1970s and 1980s era apparatus was also calculated and compared to that of the new apparatus. As shown in Table C2, the new engine company design provided an increased hosebed storage capacity that ranged between 62.3% and 116.3%.

The available ground ladder storage capacity on the new apparatus was also examined. As shown in Table C2, the new engine design allowed for a 25% increase in total ground ladder storage capacity from 40 feet to 50 feet. Conversely, the new ladder company design resulted in a 62.1% decrease in total ground ladder storage capacity from 340 feet to 129 feet.

**Apparatus Pricing**

A review of Norfolk City purchase orders issued for fire apparatus during Fiscal Years 1995 through 1997, revealed varied prices for the apparatus purchased during this time period. As shown in Table C3, the unit prices paid for rescue pumpers during this time period ranged between $ 311,546.00 and $ 345,556.00, and aerial platform unit prices ranged between $ 551,546.00 and $ 627,745.00. This variation accounted for 10.9% and 13.9% total price increases respectively. One heavy rescue vehicle was purchased during Fiscal Year 1995 at a unit price of $ 341,220.00, and two aerial ladders were purchased during Fiscal Year 1996 at a unit price of $ 544,664.00. Copies of purchase orders for apparatus purchased prior to Fiscal Year 1995 were unavailable, and thus prohibited a comparative analysis of old and new apparatus pricing.

**Average Maintenance Costs**

A comparative analysis of the apparatus data in the 1993 NFPS Vehicle Study and the Norfolk Fleet Maintenance records for Fiscal Year 1997, showed a 9.1% decrease in the total maintenance costs for the NFPS fire apparatus fleet from $ 229,845.00 to $ 208,893.00, following the purchase of the new fire apparatus. As illustrated in Figure B5, specific changes in the average maintenance costs for first-line apparatus were noted: (a) engine companies--down 7.9% from $ 7,506.57 to $ 6,916.36; (b) ladder companies--down 45.1% from $ 9,911.14 to $ 5,446.14; and (c) squad companies--up 15.4% from $ 7,284.50 to $ 8,403.00. As illustrated in Figure B6, specific changes in the average maintenance costs for reserve apparatus were noted: (a) engine companies--up 10.1% from $ 6,952.50 to $ 7,654.17; (b) ladder companies--down 1.1% from $ 4,039.00 to $ 3,995.50; and (c) squad companies--up .5% from $ 1,601.00 to $ 1,609.50.

**2. What is the opinion of NFPS personnel on the performance of the new fire apparatus purchased by the department between Fiscal Years 1995 and 1997?**

As shown in Table C4, the operational performance of the new fire apparatus received average ratings of good, particularly in the areas of maneuverability, handling, acceleration, braking, ergonomics, and ease of maintenance. Driver visibility was rated less favorably and received an average rating of fair.

As shown in Table C5, the personnel accommodations of the new fire apparatus received average ratings of good, particularly in the areas of seating configuration and available space in the crew

cab areas. The communications headsets were rated as very good. However, the space availability for the driver and officer positions received a less favorable average rating of fair.

As shown in Table C6, the equipment storage capabilities of the new fire apparatus received average ratings of good, particularly in the areas of compartment space and equipment access. The roll-up compartment doors received a less favorable average rating of fair. A majority of respondents rated hosebed configurations on the rescue pumpers as good, yet rated accessibility to hose and ground ladders as fair. The access to the roof-top compartments on the heavy rescue vehicle received an average rating of good.

As shown in Table C7, specialized equipment received average ratings of very good, particularly in the areas of fire pump performance and ease of operation, aerial performance and ease of operation, and outrigger performance and ease of operation. Respondents rated the performance of foam proportioning systems and ease of operation, and compressor performance and ease of operations as good. The ease of compressor maintenance received an average rating of fair.

As shown in Table C8, ancillary equipment performance received average ratings as very good, particularly in the areas of generator performance and ease of operation. The functionality of cables/reels and the performance of the light tower on the heavy rescue each received an average rating of good. The performance of air hose and reels and the Hurst rescue system on the heavy rescue vehicle each received a less favorable average rating of fair.

As shown in Table C9, a majority of personnel agreed that the new apparatus effectively met NFPS mission requirements. A majority of personnel also agreed that the design of the new apparatus will allow flexibility in meeting changes over the next 10 years.

As shown in Table C10, a majority of personnel agreed that the NFPS should continue specifying roll-up compartment doors on all apparatus types, and foam proportioning systems, booster hose and reels, and electrical generators on all fire pumpers purchased in the future. A majority of personnel assigned to new aerial apparatus reported that they did not routinely use the level-assist feature when operating the outrigger systems. A majority of these personnel also reported that the NFPS should not incorporate additional space on future ladder company designs to carry ground ladders that are 40 to 50 feet in length. Finally, a majority of personnel assigned to the new heavy rescue vehicle agreed that a non-walk-in body design allowed more compartment space than a walk-in design, and that breathing air compressors should be included in the design of future heavy rescue vehicles. A majority of these personnel also agreed that a beverage delivery style body should not be given consideration in the design of future heavy rescue vehicles.

A number of practical suggestions were offered by NFPS personnel to improve the designs of future apparatus. These suggestions are listed in Table C11.

**3. What is the opinion of personnel from other career fire departments on the performance of new fire apparatus of similar make and models to that purchased by the NFPS?**

Four out of the five survey respondents provided information concerning the purchase price of specific types of fire apparatus. Two fire departments reported purchase prices for rescue pumpers that consisted of $ 236,000.00 and $ 284,977.00. One fire department reported a purchase price of $ 365,000.00 dollars for an aerial ladder and another department reported a purchase price of $ 558,657.00 for an aerial platform. Although some departments provided information concerning apparatus features, these results could not be effectively linked to purchase price and were considered inconclusive.

As shown in Table C12, the operational performance of fire apparatus received average ratings of very good, particularly in the areas of overall performance, apparatus quality, and customer support. Warranty resolution received an average rating of good.

As shown in Table C13, four out of five fire departments reported that they did not track vehicle down time for their new apparatus. The one fire department that did report tracking this data, did not provide any estimate of the average down time experienced with new fire apparatus. One out of five fire departments reported warranty work that required shipping the new piece of apparatus to the factory for repairs. Four fire departments reported that they would purchase the manufacturer's product again in the future, and one department reported that they were currently uncertain.

As shown in Table C14, all of the fire departments participating in the survey reported service calls for various warranty repairs. Four departments reported electrical problems, two departments reported engine problems, one department reported transmission problems, one department reported frame and suspension problems, one department reported fire pump problems, and one department

reported cab or body stress cracks. As shown in Table C15, the fire departments participating in the survey ranked the warranty problems most often experienced with new apparatus as follows: (a) electrical system, (b) engine system, (c) transmission, (d) fire pump, and (e) cab and body stress cracks.

As shown in Table C16, the operational performance of new fire apparatus received average ratings of very good, particularly in the areas of maneuverability, handling, acceleration, braking, and ergonomics. Visibility and maintenance received average ratings of good.

As shown in Table C17, the personnel accommodations of new fire apparatus received average ratings of good in the areas of seating configuration and space availability in the cab and crew cab areas.

As shown in Table C18, the equipment storage on new fire apparatus received average ratings of very good, particularly in the areas of compartment space, equipment access and hosebed configuration. The access to the hosebed received an average rating of good.

As shown in Table C19, the performance of specialized equipment on new fire apparatus received an average rating of very good, particularly in the areas of pump performance and ease of operation, aerial performance and ease of operation, and outrigger performance and ease of operation. No ratings were given on the performance or ease of operation of foam proportioning systems.

As shown in Table C20, the performance of ancillary equipment on new fire apparatus received an average rating of very good in the areas of electrical generator performance and ease of operation and the functionality of equipment reels.

As shown in Table C21, all personnel agreed that the design of the new fire apparatus met mission requirements for their fire departments.

## Discussion

The review of Norfolk City documents and records revealed that the new fire apparatus purchased between Fiscal Years 1995 and 1997 did impact the NFPS in various ways. The transition from older to newer apparatus resulted in marked decreases in the average age, mileage and maintenance costs of most first-line units. Conversely, increases in the average mileage and maintenance costs of first-line squad companies were noted. A plausible explanation for this variation was attributed to an increase in unit activity for squad companies during the same time period (see Figure B7).

The impact of new apparatus purchases on reserve units was somewhat less consistent as older first-line units were placed in reserve status and the oldest reserve units were retired from service. While the average age and mileage of reserve ladder companies decreased slightly, the average age and mileage of reserve engine companies and squad companies increased. In addition, the average maintenance costs of reserve engine companies increased while those of reserve ladder and squad companies remained fairly consistent.

A review of new apparatus features included in NFPS fire apparatus bid specifications and an associated comparison with the features of older apparatus, showed a dramatic increase in available equipment storage space on the new apparatus. Further comparisons of the bid specifications with the regulations and standards included in the Literature Review section of this report, revealed that the new apparatus designs met and in some cases exceeded the requirements of federal motor vehicle safety standards and the various fire service consensus standards that were discovered during the literature review. Norfolk's fire apparatus replacement program was also found to be consistent with the

recommendations of NFPA 1201 and 1901, and the CFAI. It was assumed that the design of new NFPS fire apparatus met or exceeded the requirements of applicable fire insurance standards, however in the absence of a copy of the ISO Fire Suppression Rating Schedule, any firm conclusions on this relationship were not possible.

Although the city's fleet maintenance facility did not track apparatus down time, records were found that listed the total number of warranty problems associated with the new apparatus. The most frequently reported warranty problem on new NFPS apparatus involved electrical systems. This finding was consistent with the warranty problems reported by fire apparatus program managers from other fire departments. It was not possible to examine differences in warranty problems between old and new NFPS apparatus designs because the data had not been tracked on units purchased prior to Fiscal Year 1995.

The cost of the new NFPS apparatus appeared to be substantially higher than that of similar make and models purchased by other municipal fire departments during the same time period. However, firm conclusions about apparatus pricing were not possible in the absence of complete information regarding the apparatus and equipment options specified by other fire departments.

The results of the NFPS user survey showed that although personnel were generally satisfied with the design and performance of the new apparatus, many were dissatisfied with the available space surrounding the driver and officer seating positions, the degree of driver visibility from within the cab, the accessibility to hose and ladder storage areas, the ease of maintenance on the SCBA mobile air compressor, and the performance of hose storage reels for the pneumatic and hydraulic systems.

Despite these concerns, a majority of the personnel surveyed agreed that the new fire apparatus effectively met NFPS mission requirements. However, some personnel noted on their surveys that they weren't certain of the exact mission for NFPS fire apparatus. Moreover, numerous practical suggestions were offered by NFPS personnel to improve the design of future apparatus.

The results of user surveys from other fire departments assigned to similar make and model fire apparatus to that purchased by the NFPS were also generally satisfied with the operational performance of their new apparatus and on average rated each criterion somewhat higher than NFPS personnel. Consistent with NFPS responses, personnel from other fire departments were somewhat less satisfied with driver visibility, ease of routine maintenance, available space in the driver and officer seating positions, and access to hosebeds. One hundred percent of personnel from other departments who responded to the survey agreed that their apparatus met the mission requirements of their department.

The results of this research project paralleled the findings of others cited in the literature review. Similar research performed by Simmons (1998) suggested that the degree of firefighter satisfaction is often directly related to the comfort level in apparatus cab and crew cab areas. In addition, the work of various authors (Brennan, 1996; Frietag, 1985; Jakubowski, 1993) noted that firefighter involvement in the design process was extremely helpful when seeking practical ideas and facilitating the acceptance of any resulting changes in the design of future fire apparatus. Furthermore, Jakubowski (1993) stressed the need to establish a definitive mission statement for a given piece of fire apparatus prior to initiating

the design process. Finally, various authors (Brennan, 1996; Carlson, 1995; Cottett, 1996; Craven, 1995) stressed simplicity and practicality in all fire apparatus designs.

The results of this research project present distinct implications for the NFPS. First, apparatus replacement forecasting methods could be enhanced through improved data collection and analysis. The results of the impact assessment of new apparatus purchases on the NFPS suggest that criteria other than age alone should be factored into all fire apparatus replacement decisions. Second, reliability assessments could be refined through improved record keeping that includes estimates on apparatus down-time for maintenance and repairs. In addition, the use of statistical control charts could be useful in gauging acceptable levels of down-time for particular types of apparatus. Third, specific changes are needed in future apparatus designs to enhance operational performance, and improve personnel accommodations and equipment storage capabilities. Fourth, the mission of each type of fire apparatus should be more closely related to the actual as opposed to the perceived needs of both the department and the community.

## Recommendations

The NFPS and Norfolk Fleet Maintenance Facility should work to improve data collection and record keeping methods on the variables that affect the service-life expectancy of fire apparatus such as age, mileage, activity levels, operating costs, maintenance costs, and down-time. This data should then be routinely analyzed and control limits for acceptable operating and maintenance costs should be

established. The evaluation of maintenance and operating costs in addition to age will strengthen apparatus replacement decisions.

The NFPS should perform a comprehensive community risk assessment to identify the actual emergency services needs of both the department and the community. Relevant information can be obtained through the department's incident reporting database, the city's Geographic Information System (GIS), and the city's planning department. The results of this risk assessment should then be used to more closely define the mission of the department's fire apparatus. A carefully defined mission in conjunction with measurable design and performance objectives, will help clarify apparatus requirements and facilitate the evaluation of future apparatus purchases.

Firefighter involvement should continue to be an essential element in the development of NFPS fire apparatus bid specifications. In addition to referencing the results of the NFPS user survey, it may be necessary to employ brainstorming or nominal group techniques to develop strategies for meeting the apparatus requirements consistent with the findings of the community risk assessment.

The design of all future NFPS fire apparatus should continue to meet or exceed all applicable federal motor vehicle safety regulations and fire service consensus standards. Additional research should be conducted to ensure that these designs are in accordance with all applicable ISO requirements as outlined in the Fire Suppression Rating Schedule.

All specified apparatus instruments, controls, specialized systems, and ancillary equipment should be closely examined and steps should be taken to simplify the operation of these devices as

needed. Likewise, impractical or unnecessary items should be removed from the bid specifications. This effort will likely improve operational performance and reduce the overall cost of new apparatus.

Major design changes are needed in apparatus cabs to improve operator visibility. This may involve changing to "bus style" mirrors, eliminating defroster fans from the windshield area, changing the configuration of map and reference book storage compartments, and providing recessed mounting positions for radios, mobile data terminals, and siren control heads.

The ability to perform routine maintenance checks should be improved in future NFPS apparatus designs. Provisions should be made to allow operators to check all engine fluid levels and add additional fluids when necessary, without having to raise apparatus cabs. Moreover, accessibility should be improved for maintenance of mobile SCBA air compressors on future heavy rescue vehicles.

Every effort should be made to improve the personnel accommodations for the operator and officer positions on all apparatus. Alternatives for increasing available cab and floor space around these seating positions should be carefully evaluated.

A number of improvements are needed to better accommodate the safe and effective storage of equipment on future NFPS apparatus. First, all hosebeds should be re-designed so that they are more accessible to the average firefighter. This may involve changes in body compartment configuration or the total elimination of the ladder storage compartment under the hosebed. Second, the width of the cross-lays should be increased to allow pre-connected hoses to be easily pulled from either side of the apparatus. Third, ground ladders stored on pumpers should be re-located so that they are more accessible to the average firefighter. Fourth, electric cable and pneumatic and hydraulic hose storage

reels should be relocated on heavy rescue vehicles to allow proper deployment and retrieval. Fifth, options for reducing overall apparatus size while maintaining existing compartment space should be closely examined.

Alternatives should be explored to minimize the risk of water entering sensitive apparatus components during flooding conditions that often accompany coastal storms in the Norfolk area. This may involve relocating engine air intakes, exhaust pipes, and electronic components.

When performing future bid evaluations, the NFPS should attempt to assess the reliability of similar apparatus produced by the bidders and purchased by other municipal fire departments. The results of this research may help strengthen recommendations for awarding bids.

Additional research should be conducted to evaluate the efficiency and effectiveness of innovative apparatus programs implemented by other municipal fire departments. Future economic realities may force the NFPS to consider alternative apparatus programs to sustain existing service levels with a reduced operating budget.

Given the significant impact that National Fire Protection Association Standards have on apparatus design and construction costs, the NFPS should consider sponsoring a department representative to serve on the NFPA 1901 committee. Fire departments that do not actively participate in the standard making process are forced to passively accept changes imposed by other representatives from both the public and private sectors.

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# Appendix A

# Inter-Department Correspondence Sheet

| | |
|---|---|
| **TO:** | **All Personnel Assigned to New Fire Apparatus Purchased Between FY-95 & FY-97** |
| **FROM:** | **Edward L. Senter Jr. - Battalion Chief, Battalion 1 "B" Shift** |
| **COPIES TO:** | **File** |
| **SUBJECT:** | **User Survey - New Fire Apparatus** |

[DATE]

The purpose of this memo is to request your assistance with a comprehensive evaluation I am currently conducting of the fire apparatus the Norfolk Department of Fire and Paramedical Services has purchased as part of a multi-year replacement program. The information obtained from this evaluation will be used to shape the design of future apparatus purchases. This information will also be included in an applied research project for the National Fire Academy as part of the Executive Fire Officer Program.

Attached to this letter is a user survey for the apparatus to which you are currently assigned. Please complete this survey and return it to me in the enclosed envelope by June 1, 1998.

Individual responses will be kept confidential. All survey responses will be consolidated to obtain a mean score for each criterion. If you have any questions, please feel free to contact me at Battalion 1 "B" Shift [WORK NUMBER]. Your assistance with this survey is appreciated.

Edward L. Senter Jr.
Battalion Chief

Enclosure

# USER SURVEY
# NORFOLK ENGINE COMPANY
# PURCHASED BETWEEN FY-95 AND FY-97

**PART I: VEHICLE PERFORMANCE RATINGS**

**Directions:** **On a scale of "1" to "5", please rate the performance of Engine [#] according to the following criteria (circle one; "5" is the highest score, and "1" is the lowest score):**

| | | | | | | |
|---|---|---|---|---|---|---|
| **A.** | **Apparatus Operational Performance** | **Poor** | **Fair** | **Good** | **Very Good** | **Excellent** |
| 1. | Maneuverability (driving, positioning) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Vehicle acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Vehicle braking performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility to controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Driver visibility (windshield/side windows, mirrors) | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **B.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for firefighter riding positions | **1** | **2** | **3** | **4** | **5** |
| 4. | David-Clark communications system (headsets) | **1** | **2** | **3** | **4** | **5** |
| **C.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| 3. | "Roll-up" compartment doors | **1** | **2** | **3** | **4** | **5** |
| 4. | Configuration of hosebeds | **1** | **2** | **3** | **4** | **5** |
| 5. | Accessibility to hose stored in hosebeds | **1** | **2** | **3** | **4** | **5** |
| 6. | Accessibility to hard suction and ground ladders | **1** | **2** | **3** | **4** | **5** |
| **D.** | **Fire Pump Performance** | | | | | |
| 1. | Overall performance of fire pump | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of fire pump operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Overall performance of foam proportioning system | **1** | **2** | **3** | **4** | **5** |
| 4. | Ease of foam proportioning system operation | **1** | **2** | **3** | **4** | **5** |

**E. Ancillary Equipment Performance**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Performance of on-board 110 volt electrical generator | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of on-board 110 volt generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Performance of electric cables and cable storage reels | **1** | **2** | **3** | **4** | **5** |

**PART II: GENERAL DESIGN QUESTIONS**

**A. Mission Requirements**

1. In your opinion, does the design of this apparatus meet the current mission requirements of an engine company in the Norfolk Department of Fire and Paramedical Services (NFPS)?

   Yes_____ No_____.

2. In your opinion, will the design of this apparatus allow flexibility in meeting possible changes in mission requirements of an engine company over the next ten years?

   Yes_____ No_____.

   If you answered "No" to Question #1 or #2, please explain:

**B. Apparatus Features**

1. Should the NFPS continue to include "roll-up" style exterior compartment doors as a design specification for future apparatus purchases?

   Yes_____ No_____.

2. Should the NFPS continue to include foam proportioning systems as a design specification for future engine company purchases?

   Yes_____ No_____.

3. Should the NFPS continue to include booster hose reels as a design specification for future engine company purchases?

   Yes_____ No_____.

4. Should the NFPS continue to include on-board 110 volt electrical generators, electrical cords and storage reels as a design specification for future engine company purchases?

   Yes_____ No_____.

**PART III: SUGGESTIONS FOR DESIGN IMPROVEMENT**

**A. Please use space below to make suggestions for design improvements for future NFPS purchases:**

# USER SURVEY
# NORFOLK LADDER COMPANY
# PURCHASED BETWEEN FY-95 AND FY-97

**PART I: VEHICLE PERFORMANCE RATINGS**

**Directions:** **On a scale of "1" to "5", please rate the performance of Ladder [#] according to the following criteria (circle one; "5" is the highest score, and "1" is the lowest score):**

| | | | | | | |
|---|---|---|---|---|---|---|
| **A.** | **Apparatus Operational Performance** | **Poor** | **Fair** | **Good** | **Very Good** | **Excellent** |
| 1. | Maneuverability (driving, positioning, set-up) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Vehicle acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Vehicle braking performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility to controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Driver visibility (windshield/side windows, mirrorrs) | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **B.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for firefighter riding positions | **1** | **2** | **3** | **4** | **5** |
| 4. | David-Clark communications system (headsets) | **1** | **2** | **3** | **4** | **5** |
| **C.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| 3. | "Roll-up" compartment doors | **1** | **2** | **3** | **4** | **5** |
| **D.** | **Aerial Device Performance** | | | | | |
| 1. | Aerial device (load capacities, operating angles, etc.) | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of aerial device operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Outrigger system (stability, set-up in tight spaces) | **1** | **2** | **3** | **4** | **5** |
| 4. | Ease of outrigger system operation | **1** | **2** | **3** | **4** | **5** |
| 5. | Ease of preventive maintenance on aerial device | **1** | **2** | **3** | **4** | **5** |

**E. Ancillary Equipment Performance**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Performance of on-board 110 volt electrical generator | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of on-board 110 volt generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Performance of electric cables and cable storage reels | **1** | **2** | **3** | **4** | **5** |

**PART II: GENERAL DESIGN QUESTIONS**

**A. Mission Requirements**

1. In your opinion, does the design of this apparatus meet the current mission requirements of a ladder company in the Norfolk Department of Fire and Paramedical Services (NFPS)?

   Yes_____ No_____.

2. In your opinion, will the design of this apparatus allow flexibility in meeting possible changes in mission requirements of an aerial ladder over the next ten years?

   Yes_____ No_____.

   If you answered "No" to Question #1 or #2, please explain:

**B. Apparatus Features**

1. Should the NFPS continue to include "roll-up" style exterior compartment doors as a design specification for future apparatus purchases?

   Yes_____ No_____.

2. Do you routinely use the "level assist" automatic leveling feature when setting the outriggers for aerial operation?

   Yes_____ No_____.

3. The complement of ground ladders carried on this apparatus meets the current requirements of NFPA 1901 for a ladder company. NFPA 1901 no longer mandates that 40' - 50' ground ladders be carried on aerial apparatus. In your opinion however, is there a need for the NFPS to design future aerial ladders with the storage space to carry a 40' or 50' ground ladder?

   Yes_____ No_____.

**PART III: SUGGESTIONS FOR DESIGN IMPROVEMENT**

**A. Please use the space below to make suggestions for apparatus design improvements for future NFPS purchases:**

# USER SURVEY
# NORFOLK SQUAD COMPANY
# PURCHASED BETWEEN FY-95 AND FY-97

**PART I: VEHICLE PERFORMANCE RATINGS**

**Directions: On a scale of "1" to "5", please rate the performance of Squad [#] according to the following criteria (circle one; "5" is the highest score, and "1" is the lowest score):**

| | | | | | | |
|---|---|---|---|---|---|---|
| **A.** | **Apparatus Operational Performance** | **Poor** | **Fair** | **Good** | **Very Good** | **Excellent** |
| 1. | Maneuverability (driving, positioning) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Vehicle acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Vehicle braking performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility to controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Driver visibility (windshield/side windows, mirrors) | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **B.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for firefighter riding positions | **1** | **2** | **3** | **4** | **5** |
| 4. | David-Clark communications system (headsets) | **1** | **2** | **3** | **4** | **5** |
| **C.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| 3. | "Roll-up" compartment doors | **1** | **2** | **3** | **4** | **5** |
| 4. | Accessibility to "rooftop" compartments | **1** | **2** | **3** | **4** | **5** |
| **D.** | **SCBA Air Compressor/Fill Station Performance** | | | | | |
| 1. | Performance of air compressor/fill station | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of air compressor/fill-station operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Ease of routine maintenance checks (fluids, filters, etc.) | **1** | **2** | **3** | **4** | **5** |
| **E.** | **Ancillary Equipment Performance** | | | | | |
| 1. | Performance of on-board 110 volt electrical generator | **1** | **2** | **3** | **4** | **5** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2. | Ease of on-board 110 volt generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Performance of light tower | **1** | **2** | **3** | **4** | **5** |
| 4 | Performance of electric cables and storage reels | **1** | **2** | **3** | **4** | **5** |
| 5. | Performance of air systems and storage reels | **1** | **2** | **3** | **4** | **5** |
| 6. | Performance of on-board Hurst system and reels | **1** | **2** | **3** | **4** | **5** |

**PART II: GENERAL DESIGN QUESTIONS**

**A. Mission Requirements**

1. In your opinion, does the design of this apparatus meet the current mission requirements of a squad company in the Norfolk Department of Fire and Paramedical Services (NFPS)?

   Yes_____ No_____.

2. In your opinion, will the design of this apparatus allow flexibility in meeting possible changes in mission requirements of a squad company over the next ten years?

   Yes_____ No_____.

   If you answered "No" to Question #1 or #2, please explain:

**B. Apparatus Features**

1. Should the NFPS continue to include "roll-up" style exterior compartment doors as a design specification for future apparatus purchases?

   Yes_____ No_____.

2. In your opinion, does the design of Squad 2 (non-walk-in body style) allow more equipment storage space than the design of Squad 1 (walk-in body style)?

   Yes_____ No_____.

3. Should the NFPS continue to include mobile air compressors as a design specification for future squad company purchases?

   Yes_____ No_____.

4. Should the NFPS consider changing to a "beverage delivery truck" style body design (i.e. Hackney, Betten, etc.) to maximize equipment storage space for future squad company purchases?

   Yes_____ No_____.

**PART III: SUGGESTIONS FOR DESIGN IMPROVEMENT**

**A. Please use the space below to make suggestions for apparatus design improvements for future NFPS purchases:**

[DATE]

Dear :

I would like to request your assistance with a fire apparatus survey, currently being conducted by the Norfolk Department of Fire and Paramedical Services. The purpose of this survey is twofold: (1) to evaluate the performance and reliability of Norfolk's newest fire apparatus in comparison with similar make/model apparatus purchased by other municipalities; and (2) to obtain data for an applied research project as part of the Executive Fire Officer Program at the National Fire Academy.

Between Fiscal Years 1995 and 1997, the City of Norfolk purchased the following fire apparatus from [MANUFACTURER]: [MODEL # ENGINE, MODEL # LADDER, MODEL # AERIAL PLATFORM, MODEL # HEAVY RESCUE]. Customer lists provided by [MANUFACTURER], show that your department purchased the following similar apparatus during the same time period:

Enclosed with this letter is an apparatus program manager survey, and a user survey for each [MANUFACTURER] vehicle purchased by your department between 1994 and 1998. Will you please forward the program manager survey to whomever in your department is responsible for overseeing fire apparatus design and procurement? Also, will you have one company officer or firefighter who is assigned to each of the apparatus listed above, complete a user survey for that apparatus? Please return completed surveys in the enclosed envelope, or fax them to me at [FAX NUMBER] by June 10, 1998.

Individual responses to these surveys will be kept confidential. Responses from all municipalities surveyed will be consolidated to obtain a mean score for each category. If you have any questions, please feel free to contact me at work [WORK NUMBER] or at home [HOME NUMBER]. Your assistance with this survey is appreciated.

Sincerely,

Edward L. Senter Jr.
Battalion Chief

Enclosures

# APPARATUS PROGRAM MANAGER SURVEY
# FOR FIRE DEPARTMENTS PURCHASING SIMILAR APPARATUS
# DURING FY-95, FY-96, AND FY-97

## I. Apparatus Pricing

1. Please list the bid price of the fire apparatus recently purchased by your department from [MANUFACTURER], according to the following model(s) and order number(s):

   A. [MODEL #] [VEHICLE TYPE] (#, ordered [MONTH/YEAR]):_____.

   Note: Does this vehicle have any of the following features? (check all that apply):

   | | |
   |---|---|
   | Rescue style compartments:____. | SCBA cascade system:____. |
   | Roll-up compartment doors:____. | Mobile air compressor:____. |
   | On-board electrical generators:____. | Foam proportioning system:____. |
   | On-board hydraulic rescue systems:____. | Communications system(i.e. David Clark, etc.):____. |

## II. Apparatus Performance

1. In your opinion, please rate the overall operational performance of the fire apparatus your department has purchased from [MANUFACTURER] (circle one):

   | Poor | Fair | Good | Very Good | Excellent |
   |---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 |

2. In your opinion, please rate the quality of the [MANUFACTURER] product line (circle one):

   | Poor | Fair | Good | Very Good | Excellent |
   |---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 |

## III. Warranty Service

1. Does your department track vehicle “down time” for new fire apparatus due to repairs or service?

   Yes_____ No_____.

   If yes, what is the average “down time” for your new [MANUFACTURER] apparatus?_____.

2. In your opinion, please rate the responsiveness of your [MANUFACTURER] dealer in resolving warranty problems (circle one):

   | Poor | Fair | Good | Very Good | Excellent |
   |---|---|---|---|---|
   | 1 | 2 | 3 | 4 | 5 |

3. Please indicate the types of service calls for warranty repairs your department has experienced with the apparatus purchased from [MANUFACTURER] (check all that apply):

   | | | | |
   |---|---|---|---|
   | a. | Engine:____. | e. | Pump:____. |
   | b. | Transmission:____. | f. | Aerial/Outrigger System:____. |
   | c. | Electrical:____. | g. | Cab/body stress cracks:____. |
   | d. | Frame/suspension:____. | h. | Component parts (i.e. generators, etc):____. |

4. Based on the types of service calls that you checked when answering Question #3, please list the most frequent types of service calls your department has experienced in descending order (#1=most frequent, #5=least frequent):

   #1:_____. #4:_____.

   #2:_____. #5:_____.

   #3:_____.

5. Have any of the fire apparatus purchased by your department from [MANUFACTURER] experienced warranty problems that required shipment back to the factory for repair?

   Yes_____ No_____ .

   If yes, please list vehicle type(s) and explain reason(s):

## IV. Customer Satisfaction

1. In your opinion, please rate how well [MANUFACTURER] stands behind their product and provides customer support in resolving apparatus performance issues?(circle one):

| **Poor** | **Fair** | **Good** | **Very Good** | **Excellent** |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

2. Will you likely purchase fire apparatus from [MANUFACTURER] again in the future?

   Yes_____ No_____ Uncertain_____.

# USER SURVEY
# FOR FIRE DEPARTMENTS PURCHASING SIMILAR APPARATUS DURING FY-95, FY-96, AND FY-97

**Model:** [TYPE] Rescue Pumper **#:**_____ **Date of Delivery:**

**Directions:** **Please rate the fire apparatus listed above according to the following performance criteria, on a scale of "1" to "5" (circle one). "5" is the highest score, and "1" is the lowest score. Do not rate areas that do not apply to this specific apparatus (i.e. generators, cascade systems, etc.)**

| | | Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|---|---|
| **I.** | **Apparatus Operational Performance** | | | | | |
| 1. | Maneuverability (driving, positioning, set-up) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Brake performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility of controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Windshield/window visibility | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **II.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for crew positions | **1** | **2** | **3** | **4** | **5** |
| **III.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| 3. | Amount of hosebed space | **1** | **2** | **3** | **4** | **5** |
| 4. | Accessibility to hose stored in hosebeds | **1** | **2** | **3** | **4** | **5** |
| **IV.** | **Fire Pump Performance** | | | | | |
| 1. | Overall performance of fire pump | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of fire pump operation | **1** | **2** | **3** | **4** | **5** |
| **V.** | **Ancillary Equipment Performance** | | | | | |
| 1. | Overall performance of on-board generator | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Functionality of equipment reels | **1** | **2** | **3** | **4** | **5** |

Does the design of this vehicle meet the mission requirements in your fire department? Yes_____ No_____.

# USER SURVEY
# FOR FIRE DEPARTMENTS PURCHASING SIMILAR APPARATUS
# DURING FY-95, FY-96, AND FY-97

**Model:** [TYPE] Aerial Ladder/Platform **#:**_____ **Date of Delivery:**

**Directions:** **Please rate the fire apparatus listed above according to the following performance criteria, on a scale of "1" to "5" (circle one). "5" is the highest score, and "1" is the lowest score. Do not rate areas that do not apply to this specific apparatus (i.e. generators, cascade systems, etc.)**

| | | Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|---|---|
| **I.** | **Apparatus Operational Performance** | | | | | |
| 1. | Maneuverability (driving, positioning, set-up) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Brake performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility of controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Windshield/window visibility | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **II.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for crew positions | **1** | **2** | **3** | **4** | **5** |
| **III.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| **IV.** | **Aerial Device Performance** | | | | | |
| 1. | Overall performance of aerial device | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of outrigger operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Ease of aerial device operation | **1** | **2** | **3** | **4** | **5** |
| **V.** | **Ancillary Equipment Performance** | | | | | |
| 1. | Overall performance of on-board generator | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Functionality of equipment reels | **1** | **2** | **3** | **4** | **5** |

Does the design of this vehicle meet the mission requirements in your fire department? Yes_____ No_____.

# USER SURVEY
# FOR FIRE DEPARTMENTS PURCHASING SIMILAR APPARATUS
# DURING FY-95, FY-96, AND FY-97

**Model:** [TYPE] Heavy Rescue **#:**_____ **Date of Delivery:**

**Directions:** **Please rate the fire apparatus listed above according to the following performance criteria, on a scale of "1" to "5" (circle one). "5" is the highest score, and "1" is the lowest score. Do not rate areas that do not apply to this specific apparatus (i.e. generators, cascade systems, etc.)**

| | | Poor | Fair | Good | Very Good | Excellent |
|---|---|---|---|---|---|---|
| **I.** | **Apparatus Operational Performance** | | | | | |
| 1. | Maneuverability (driving, positioning, set-up) | **1** | **2** | **3** | **4** | **5** |
| 2. | Vehicle handling characteristics | **1** | **2** | **3** | **4** | **5** |
| 3. | Acceleration performance | **1** | **2** | **3** | **4** | **5** |
| 4. | Brake performance | **1** | **2** | **3** | **4** | **5** |
| 5. | Ergonomics (accessibility of controls and instruments) | **1** | **2** | **3** | **4** | **5** |
| 6. | Windshield/window visibility | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of routine maintenance checks (fluids, etc.) | **1** | **2** | **3** | **4** | **5** |
| **II.** | **Personnel Accommodations** | | | | | |
| 1. | Seating configuration | **1** | **2** | **3** | **4** | **5** |
| 2. | Available space for driver and officer positions | **1** | **2** | **3** | **4** | **5** |
| 3. | Available space for crew positions | **1** | **2** | **3** | **4** | **5** |
| **III.** | **Equipment Storage** | | | | | |
| 1. | Amount of compartment space | **1** | **2** | **3** | **4** | **5** |
| 2. | Accessibility to equipment stored in compartments | **1** | **2** | **3** | **4** | **5** |
| **IV.** | **Ancillary Equipment Performance** | | | | | |
| 1. | Overall performance of on-board generator | **1** | **2** | **3** | **4** | **5** |
| 2. | Ease of generator operation | **1** | **2** | **3** | **4** | **5** |
| 3. | Functionality of equipment reels | **1** | **2** | **3** | **4** | **5** |
| 4. | Overall performance of mobile air compressor | **1** | **2** | **3** | **4** | **5** |
| 5. | Ease of mobile air compressor operation | **1** | **2** | **3** | **4** | **5** |
| 6. | Overall performance of SCBA cascade system | **1** | **2** | **3** | **4** | **5** |
| 7. | Ease of SCBA cascade system operation | **1** | **2** | **3** | **4** | **5** |

Does the design of this vehicle meet the mission requirements in your department? Yes_____ No_____.

# Appendix B

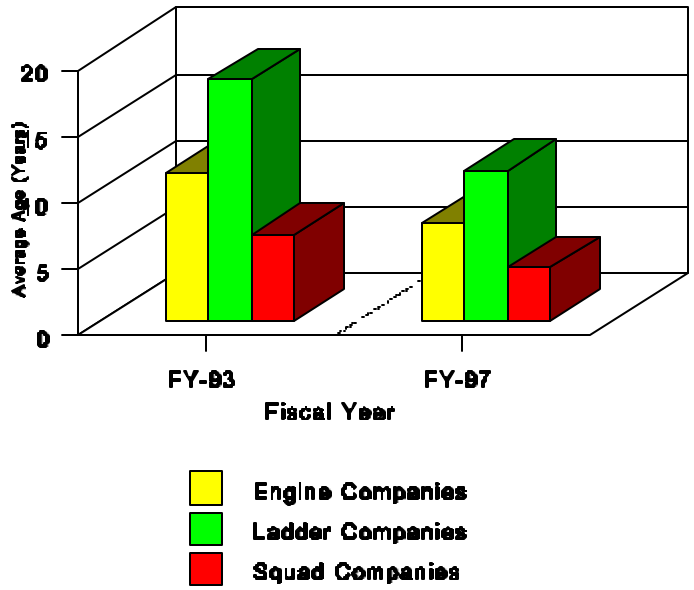
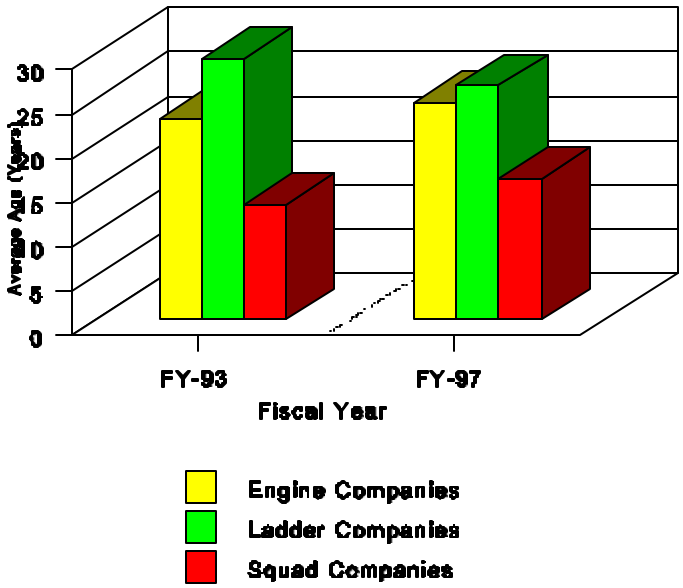



Figure B1. Changes in the average ages of NFPS first-line fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.



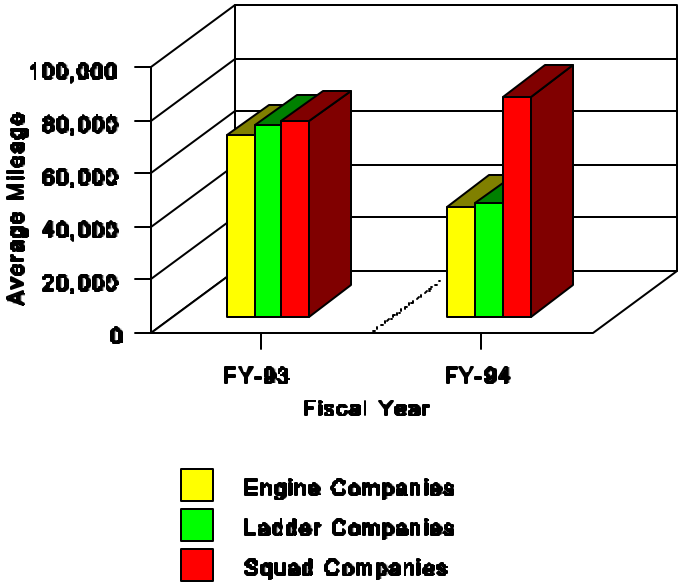



Figure B2. Changes in the average ages of NFPS reserve fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.

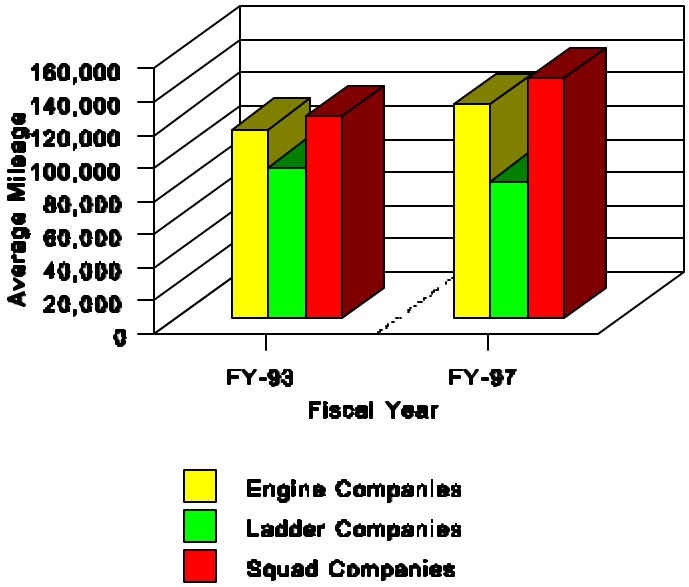



Figure B3. Changes in the average mileage of NFPS first-line fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.

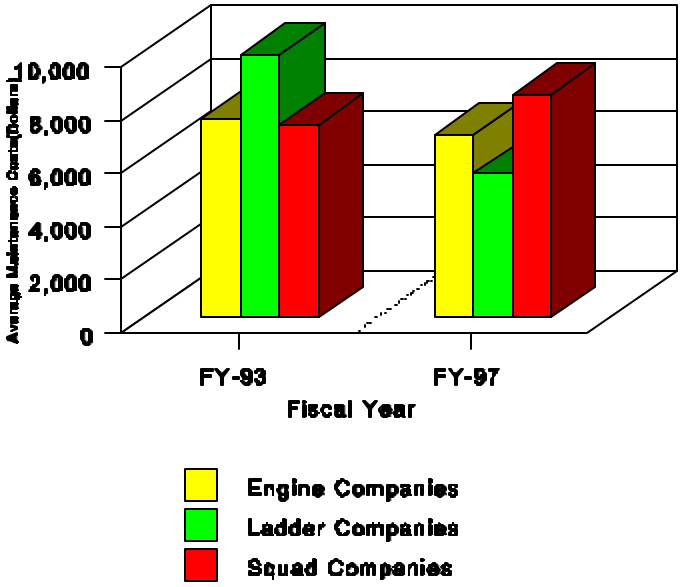



Figure B4. Changes in the average mileage of NFPS reserve fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.

Figure B5. Changes in the average maintenance costs of NFPS first-line fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.

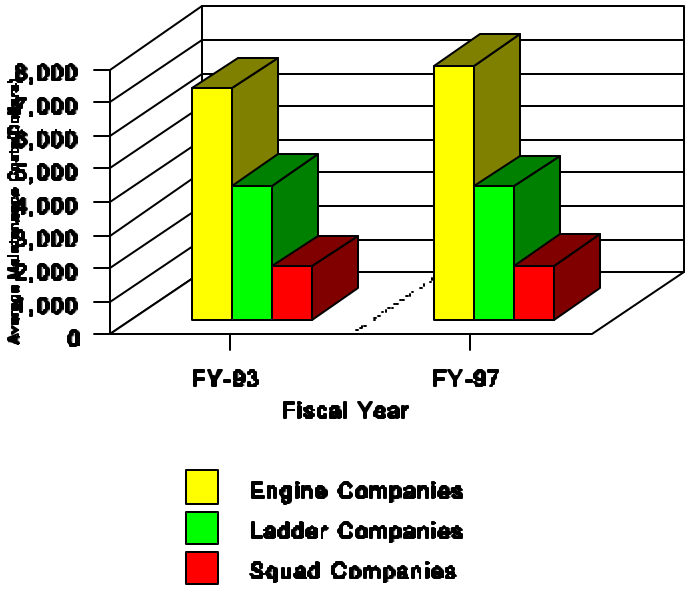



Figure B6. Changes in the average maintenance costs of NFPS reserve fire apparatus following the purchase of new apparatus between Fiscal Years 1995 and 1997.

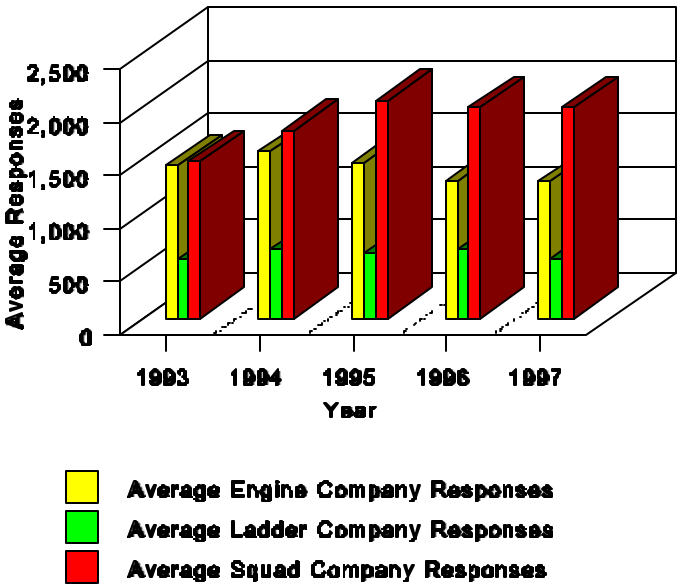



Figure B7. Average responses by NFPS fire apparatus by unit type for each year between 1993 and 1997.

# Appendix C

Table C1

Reported Warranty Problems by Type on New NFPS Fire Apparatus

| Type of Warranty Problem | No. of Reported Problems | % of Reported Problems |
|---|---|---|
| Electrical System | 54 | 43.9% |
| Body/Cab Components | 16 | 13.0% |
| Defects in Metal or Welds | 11 | 8.9% |
| Engine | 8 | 6.5% |
| Ancillary Equipment | 8 | 6.5% |
| Aerial/Outrigger System | 6 | 4.9% |
| Brake System | 6 | 4.9% |
| Pump | 5 | 4.1% |
| Compartment Doors | 5 | 4.1% |
| Transmission | 2 | 1.6% |
| Suspension | 2 | 1.6% |
| Steering | | |

Table C2

NFPS Fire Apparatus Equipment Storage Comparisons - Old vs. New Designs

| Criterion | Old Design | New Design | % Change |
|---|---|---|---|
| Compartment Space - Eng. Co.'s | 53.5 - 110.6 $ft^3$ | 141.7 $ft^3$ | 28.1 - 164.9% |
| Compartment Space - Lad. Co.'s | 120.2 - 250.2 $ft^3$ | 316.2 - 324.3 $ft^3$ | 29.6 - 163.1% |
| Compartment Space - Sqd. Co.'s | 474.7 $ft^3$ | 541.7 $ft^3$ | 14.1% |
| Hosebeds - Eng. Co.'s | 65.8 - 87.7 $ft^3$ | 142.3 $ft^3$ | 62.3 - 116.3% |
| Ground Ladders - Eng. Co.'s | 40' | 50' | 25.0% |
| Ground Ladders - Lad. Co.'s | 340' | 129' | -62.1% |

Table C3

Unit Price Comparisons of New Fire Apparatus Purchased Between Fiscal Years 1995 and 1997

| Apparatus Type | Unit Price FY-95 | Unit Price FY-96 | Unit Price FY-97 | % Change FY-95 to FY-97 |
|---|---|---|---|---|
| 1500 GPM Pumper | 311,546.00 | 335,349.00 | 345,556.00 | 10.9% |
| Aerial Platform | 551,208.00 | | 627,745.00 | 13.9% |
| Aerial Ladder | | 544,664.00 | | |
| Heavy Rescue | 341,220.00 | | | |

Table C4

Operational Performance Ratings on New NFPS Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Maneuverability | .8% | 3.3% | 25.4% | 55.7% | 14.8% | 3.8 |
| Handling | | 1.6% | 27.9% | 55.7% | 14.8% | 3.8 |
| Acceleration | 1.6% | 11.5% | 27.0% | 38.5% | 21.39% | 3.7 |
| Braking | | 4.1% | 31.1% | 45.9% | 18.9% | 3.8 |
| Ergonomics | 1.6% | 7.4% | 38.5% | 39.3% | 13.1% | 3.5 |
| Visibility | 12.3% | 27.0% | 26.2% | 24.6% | 9.8% | 2.9 |
| Maintenance | 3.3% | 22.1% | 42.6% | 28.7% | 3.3% | 3.1 |

Table C5

Personnel Accommodations Ratings on New NFPS Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Seating Config. | 4.1% | 13.9% | 41.0% | 30.3% | 10.7% | 3.3 |
| Space - Front | 45.1% | 23.0% | 18.0% | 8.2% | 55.7% | 2.1 |
| Space - Rear | 4.9% | 8.2% | 18.9% | 41.8% | 26.2% | 3.8 |
| Communications | .8% | 3.3% | 22.1% | 32.8% | 41.0% | 4.1 |

Table C6

Equipment Storage Ratings on New NFPS Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Compt. Space | | 4.9% | 20.5% | 51.6% | 23.0% | 3.9 |
| Equip. Access | | 6.6% | 32.0% | 41.8% | 19.7% | 3.7 |
| Compt. Doors | 18.0% | 19.7% | 32.8% | 25.4% | 4.1% | 2.8 |
| Hosebed Config. | 13.0% | 19.5% | 44.2% | 18.2% | 5.2% | 3.2 |
| Hosebed Access | 32.5% | 23.4% | 35.1% | 6.5% | 2.6% | 2.2 |
| Ground Ladders | 11.7% | 26.0% | 36.4% | 18.2% | 7.8% | 2.8 |
| Roof Compts. | 7.1% | 7.1% | 28.6% | 42.9% | 14.3% | 3.5 |

Table C7

Specialized Equipment Performance Ratings on New NFPS Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Pump Perf. | | | 19.5% | 40.3% | 40.3% | 4.2 |
| Pump Operation | | | 20.8% | 41.6% | 37.1% | 4.2 |
| Foam Perf. | 3.9% | 6.5% | 39.0% | 24.7% | 26.0% | 3.6 |
| Foam Operation | 2.6% | 6.5% | 39.0% | 26.0% | 26.0% | 3.7 |
| Aerial Perf. | | | 9.7% | 38.7% | 51.6% | 4.4 |
| Aerial Operation | | | 16.1% | 41.9% | 41.9% | 4.3 |
| Outrigger Perf. | | 3.2% | 19.4% | 32.3% | 45.2% | 4.2 |
| Outrigger Oper. | | 3.2% | 12.9% | 38.7% | 45.2% | 4.3 |
| Aerial Maintenance | 3.2% | 12.9% | 22.6% | 38.7% | 27.6% | 3.7 |
| Comp. Perf. | | 7.1% | 14.3% | 57.1% | 21.4% | 3.9 |
| Comp. Operation | | 7.1% | 28.6% | 42.9% | 21.4% | 3.8 |
| Comp. Maint. | 14.3% | 21.4% | 28.6% | 28.6% | 17.1% | 2.9 |

Table C8

Ancillary Equipment Performance Ratings on New NFPS Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Generator | .8% | 1.6% | 23.0% | 41.8% | 32.8% | 4.0 |
| Generator Oper. | | 1.6% | 19.7% | 44.3% | 34.4% | 4.1 |
| Cables/Reels | 4.1% | 8.2% | 21.3% | 42.6% | 23.8% | 3.7 |
| Light Tower | | 14.3% | 14.3% | 71.4% | | 3.6 |
| Air Hose/Reels | 21.4% | 35.7% | 21.4% | 21.4% | | 2.4 |
| Hurst System | 42.9% | 35.7% | 7.1% | 7.1% | 7.1% | 2.0 |

Table C9

Ratings of Mission Requirements of New NFPS Fire Apparatus

| Question | Yes | No |
|---|---|---|
| Does the design of apparatus meet NFPS mission requirements? | 95.9% | 4.1% |
| Will design allow flexibility to meet changes over next 10 years? | 86.1% | 13.9% |

Table C10

Ratings of Apparatus Features on New NFPS Fire Apparatus

| Question | Yes | No |
|---|---|---|
| Should NFPS continue specifying “roll-up” compartment doors? | 67.2% | 32.8% |
| Should NFPS continue specifying foam proportioning systems? | 83.1% | 16.9% |
| Should NFPS continue specifying booster hose and reels? | 88.3% | 11.7% |
| Should NFPS continue specifying generators on engine co.’s? | 93.5% | 6.5% |
| Do you routinely use “level assist” when setting outriggers? | 35.5% | 64.5% |
| Should NFPS ladder companies carry 40' - 50' ground ladders? | 19.4% | 80.6% |
| Does “non-walk-in” body allow more equipment storage space? | 71.4% | 28.6% |
| Should NFPS continue specifying compressors for squad co.’s? | 100% | |
| Should NFPS consider “beverage delivery” style body for future? | 28.6% | 71.4% |

Table C11

Suggestions for Improvement of Future NFPS Fire Apparatus Designs

| Suggested Improvement | No. of Responses |
|---|---|
| Increase avaialable space at officer’s seating position | 34 |
| Lower hosebed height | 15 |
| Purchase roll-up doors from different manufacturer | 13 |
| Improve driver visibility in cab | 12 |
| Improve electrical system | 10 |
| Re-configure cross-lays | 10 |
| Simplify apparatus instruments and controls | 9 |
| Increase available space at operator’s seating position | 8 |
| Improve ability to perform maintenance checks without tilting cab | 7 |

| | |
|---|---|
| Re-locate reels for electrical, pnuematic and hydraulic systems on heavy rescue | 6 |
| Make booster hose easier to reach | 6 |
| Delete tool compartment in crew cab; mount tools on cab wall | 6 |
| Lower ladder storage compartments | 4 |
| Move engine air intakes higher to prevent entry of water during flooding conditions | 4 |
| Pipe foam system to one or two outlets | 2 |
| Delete foam system | 1 |
| Specify diesel powered generators at opposed to hydraulic generators | 1 |
| Widen crew cab doors | 1 |
| Widen crew cab steps | 1 |
| Move EMS equipment inside crew cab | 1 |
| Lower overall height of engine companies | 1 |
| Increase quantity of ground ladders on aerial apparatus | 1 |
| Add front suction | 1 |
| Have all crew seats face forward | 1 |

Table C12

Program Manager Ratings - Fire Departments Purchasing Similar Make and Models of Fire Apparatus

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Overall Performance | | 20% | | 40% | 40% | 4.0 |
| Apparatus Quality | | 20% | | 40% | 40% | 4.0 |
| Warranty Resolution | 20% | 20% | | 20% | 40% | 3.4 |
| Customer Support | | 20% | 20% | | 60% | 4.0 |

Table C13

Responses to General Questions from Program Manager Surveys of Fire Departments Purchasing Similar Make and Models of Fire Apparatus

| Criterion | Yes | No | Uncertain |
|---|---|---|---|
| Does your department track vehicle "down time?" | 20% | 80% | |
| Have any repairs been completed at factory? | 20% | 80% | |
| Will you purchase manufacturer's product again? | 80% | | 20% |

Table C14

Identification of Warranty Problems by Type from Program Manager Surveys of Fire Departments Purchasing Similar Make and Models of Fire Apparatus

| Type of Warranty Problem | No. of Customers Experiencing Problems |
|---|---|
| Electrical System | 4 |
| Engine System | 2 |
| Transmission | 1 |
| Frame/Suspension System | 1 |
| Pump | 1 |
| Cab/Body Stress Cracks | 1 |

Table C15

Ranking of Warranty Problems Most Often Experienced by Fire Departments Purchasing Similar Make and Models of Fire Apparatus

| Type of Warranty Problem | Rank |
|---|---|
| Electrical System | 1 |
| Engine System | 2 |
| Transmission | 3 |
| Pump | 4 |
| Cab/Body Stress Cracks | 5 |

Table C16

Operational Performance Ratings on Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Maneuverability | | 7.1% | 21.4% | 21.4% | 50.0% | 4.1 |
| Handling | | 14.3% | 7.1% | 35.7% | 42.9% | 4.1 |
| Acceleration | | 7.1% | 7.1% | 35.7% | 50.0% | 4.3 |
| Braking | | | 14.3% | 35.7% | 50.0% | 4.4 |
| Ergonomics | | 7.1% | 7.1% | 64.3% | 21.4% | 4.0 |
| Visibility | 7.1% | 7.1% | 35.7% | 50.0% | | 3.3 |
| Maintenance | 7.1% | 7.1% | 14.3% | 50.0% | 21.4% | 3.7 |

Table C17

Personnel Accommodations Ratings on Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Seating Config. | 14.3% | | 21.4% | 35.7% | 28.6% | 3.6 |
| Space - Front | 21.4% | | 21.4% | 35.7% | 21.4% | 3.4 |
| Space - Rear | | 7.1% | 50.0% | 28.6% | 14.3% | 3.5 |

Table C18

Equipment Storage Ratings on Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Compt. Space | | | 21.4% | 35.7% | 42.9% | 4.2 |
| Equip. Access | | | 28.6% | 7.1% | 64.3% | 4.4 |
| Hosebed Config. | | 9.1% | 9.1% | 27.3% | 54.5% | 4.3 |
| Hosebed Access | 9.1% | | 45.5% | 36.4% | 9.1% | 3.4 |

Table C19

Specialized Equipment Performance Ratings on Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Pump Perf. | | | 9.1% | 81.8% | 9.1% | 4.0 |
| Pump Operation | | | | 90.9% | 9.1% | 4.1 |
| Foam Perf. | | | | | | |
| Foam Operation | | | | | | |
| Aerial Perf. | | | | 66.7% | 33.3% | 4.3 |
| Outrigger Oper. | | | | 66.7% | 33.3% | 4.3 |
| Aerial Oper. | | | | 66.7% | 33.3% | 4.3 |

Table C20

Ancillary Equipment Performance Ratings on Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Criterion | Poor | Fair | Good | Very Good | Excellent | Mean Score |
|---|---|---|---|---|---|---|
| Generator | | | | 66.7% | 33.3% | 4.3 |
| Generator Oper. | | | | 66.7% | 33.3% | 4.3 |
| Equip. Reels | | | | 66.7% | 33.3% | 4.3 |

Table C21

Ratings of Mission Requirements of Similar Make and Models of Fire Apparatus Purchased by Other Municipal Fire Departments

| Question | Yes | No |
|---|---|---|
| Does the design of apparatus meet mission requirements? | 100.0% | |